PROJECT MANUAL FOR:
University of Missouri
Middlebush Farm - Nextgen Center of Excellence for Influenza Research, Phase II

PROJECT NUMBER:
CP230831

AT:
UNIVERSITY OF MISSOURI – COLUMBIA
COLUMBIA, MISSOURI

FOR:
THE CURATORS OF THE UNIVERSITY OF MISSOURI

PREPARED BY:
Clark & Enersen
Architect of Record
2020 Baltimore Ave, Suite 300
Kansas City, MO 64108
816.474.8237

Clark & Enersen
Mechanical, Plumbing, & Electrical Engineer of Record
2020 Baltimore Ave, Suite 300
Kansas City, MO 64108
816.474.8237

SK Design Group, Inc.
Civil Engineer of Record
4600 College Boulevard, Suite 100
Overland Park, KS 66211913.451.1818

Leigh + O'Kane
Structural Engineer of Record
250 NE Mulberry Street, Suite 201
Lee's Summit, MO 64086
816.444.3144

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VOLUME 2

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SECTION 21 05 00 - BASIC FIRE SUPPRESSION REQUIREMENTS

1. GENERAL

1.1 SECTION INCLUDES

A. This section describes Basic Fire Suppression Requirements required to provide for a complete installation of all fire suppression systems for this project. This section shall apply to all other Division 21 specification sections as well as all work shown on the drawings.

B. It is the intent of the Fire Suppression Division of the Specifications that all mechanical work specified herein be coordinated as required with the work of all other Divisions of the Specifications and Drawings so that all installations operate as designed.

C. All systems shall be completely assembled, tested, adjusted and demonstrated to be ready for operation to the satisfaction of the Owner's representative and the Authority Having Jurisdiction.

D. The Contractor shall note that, in some cases, piping as shown on the Drawings provide general location and routing information only. The Contractor shall be responsible for providing interference-free systems with proper clearance to facilities and equipment.

E. Where the word "provide" is used, it shall mean "furnish and install" unless otherwise noted or specified.

1.2 RELATED SECTIONS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this section and all other sections of Division 21.

1.3 DESCRIPTION OF WORK

A. The work included under this section consists of providing all labor, materials, supervision, and construction procedures necessary for the installation of the complete fire suppression systems required by these specifications and/or shown on the drawings of the contract.

B. The Contract Drawings are shown in part diagrammatic intended to convey the scope of work, indicating the intended general arrangement of equipment, piping, etc.

1.4 QUESTIONS OF INTERPRETATION

A. If questions arise during the bidding process regarding the meaning of any portion of the contract documents, the prospective bidder shall submit the questions to the Architect/Engineer for clarification. Any definitive interpretation or clarification of the contract documents will be published by addenda, properly issued to each person holding documents, prior to the bid date. Verbal interpretation or explanation not issued in the form of an addendum shall not be considered part of the bidding documents. When submitting questions for clarification, adequate time for issuance and delivery of addenda must be allowed.

B. The Architect/Engineer shall be the sole judge regarding interpretations of conflicts within contract documents.

1.5 CONTRACT DOCUMENT DISCREPANCIES

A. If any ambiguities should appear in the contract documents, the Contractor shall request clarification from the Architect/Engineer before proceeding with the work. If the Contractor fails to make such request, no excuse will thereafter be entertained for failure to carry out the work in a manner satisfactory to the Architect/Engineer. Should a conflict occur within the contract documents, the Contractor is deemed to have estimated the more expensive way of doing the work unless a written clarification from the Architect/Engineer was requested and obtained before submission of bid.

B. The Contractor acknowledges and understands that the Contract Documents are a two-dimensional representation of three-dimensional objects. This representation may include imperfect data, interpreted codes, utility guidelines, three-dimensional conflicts, and required field coordination items. Such deficiencies should be 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.

C. The Contractor shall follow the drawings in laying out work and verify clearances for the installation of the materials and equipment based on the dimensions of actual equipment furnished. Whenever a question exists as to the exact intended location of materials or equipment, obtain instructions from the Architect/Engineer before proceeding with the work.

D. If there is a conflict between manufacturer's recommendations and the Contract Documents, the manufacturer's recommendations shall govern with no additional cost to the Owner.

1.6 PERMITS

A. The Contractors shall familiarize themselves with all requirements regarding all permits, fees, etc., and shall comply with them. All permits, licenses, inspections and arrangements required for the work shall be obtained by the Contractor at his expense.

B. All utilities shall be installed in accordance with the local rules and regulations and all charges shall be paid by the Contractor.

1.7 QUALITY ASSURANCE

A. Installers shall have at least 2 years of successful installation experience on projects with fire suppression installation work similar to that required by the project. All equipment and materials shall be installed in a neat and workmanlike manner and shall be aligned, leveled, and adjusted for satisfactory operation, unless noted otherwise in other fire suppression sections.

B. Manufacturer of equipment and materials must be regularly engaged in the manufacture of the specified equipment and material with similar construction and capacities and whose products have been in satisfactory use in similar service for not less than five (5) years, unless noted otherwise in other Fire Suppression Sections.

C. Qualify welding processes and operators for structural steel according to AWS D1.1. "Structural Welding Code - Steel.

D. Quality welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."

E. Comply with provisions of NFPA 13, NFPA 14, and NFPA 24, including all addenda.

F. Contractor signed welder certificate(s) shall be submitted. Certify that each welder has passed AWS qualification tests for the welding processes involved and that certification is current. A record shall be maintained on the job site showing the date and results of qualification tests for each welder employed on the job. One certified copy of the qualification test for each welder so employed shall be furnished to the Owner's representative.

1.8 REFERENCES

A. The design, manufacture, testing, and method of installation of all equipment and materials furnished under the requirements of this specification shall, at minimum, conform to the following as applicable:

1. Safety and Health Regulations for Construction.
2. Occupational Safety and Health Standards, National Consensus Standards and Established Federal Standards.
3. ACGIH - American Conference of Governmental Industrial Hygienists.
4. AIHA - American Industrial Hygiene Association.
5. AMCA - Air Movement and Control Association.
6. ANSI - American National Standards Institute.
7. ASA - Acoustical Society of American.
8. ASHRAE - American Society of Heating, Refrigerating, and Air-Conditioning Engineers.
9. ASME - The American Society of Mechanical Engineers.
10. ASTM - American Society of Testing and Materials.
11. CAGI - Compressed Air and Gas Institute.
12. CTI - Cooling Tower Institute.
13. EJMA - Expansion Joint Manufacturers Association.

14. ETL - Engineering Tests Laboratory.
15. HI - Hydraulic Institute.
16. HYD I - Hydronics Institute.
17. ICBO - International Conference of Building Officials.
18. ICC – International Code Council.
19. NEBB - National Environmental Balancing Bureau.
20. NEC - National Electrical Code.
21. NEMA - National Electrical Manufacturers Association.
22. NFPA - National Fire Protection Association.
23. NSF - National Sanitation Foundation.
24. SAE - Society of Automatic Engineers.
25. SMACNA - Sheet Metal and Air Conditioning Contractors' National Association.
26. TEMA - Tubular Exchanger Manufacturers Association.
27. UL - Underwriters Laboratories, Inc.
28. International Plumbing Code.
29. International Mechanical Code.
30. Other governing, state, and local codes that apply.

1.9 SUBMITTALS

A. General: Follow the procedures specified in Division 1 Sections "General Conditions" and “Special Conditions”.

1. See Section 21 13 13 for special submittal procedures for sprinkler/standpipe system submittals.

B. The Architect/Engineer’s review of submittals, including any corrections or comments made on the shop drawings during the review process, do not relieve Contractor from compliance with requirements of the Contract Documents. The review is only a review of general conformance with the design concept of the project and general compliance with the information given in the Contract Documents. The Contractor is responsible for confirming and correlating all quantities and dimensions; selecting fabrication process and techniques of construction; coordinating his work with that of all other trades; and performing his work in a safe and satisfactory manner. The Contractor shall not be relieved from responsibility for errors or omissions in the shop drawings, product data or samples by the Architect/Engineer’s review of those drawings.

C. No portion of the work requiring submission of a shop drawing, product data or sample shall be commenced until the submittal has been reviewed by the Architect/Engineer. All such portions of the work shall be in accordance with reviewed submittals and the associated manufacturer recommendations.

D. Shop drawings shall include the minimum following information as applies. Additional specific information required is outlined in other Fire Suppression Sections.

1. Certified performance and data with system operating conditions indicated.

2. All equipment items shall be marked with the same item number as used on drawings or schedules.
3. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicating, weights (shipping, installed, and operating), furnished specialties and accessories; and installation and start-up instructions.
4. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loading, required clearances, and methods of assembly of components.
5. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to electrical equipment. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring required for final installation of electrical equipment and controls. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
6. Maintenance Data: Submit maintenance data and parts list for each fire suppression equipment, control and accessory; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual; in accordance with requirements of Division 1.

E. Coordination drawings

1. Drawings:

a. Provide coordination in determining adequate clearance and space requirements for fire suppression equipment, mechanical equipment, electrical equipment, and other items/equipment in the project. The Architect/Engineer reserves the right to determine space priority of equipment in the event of interference between pieces of equipment, piping, conduit, ducts and equipment of the trades. The Architect/Engineer will only review conflicts and give an opinion but will not perform as a coordinator.

b. Provide coordination drawings indicating new and existing structural components, reflected ceiling layout, fire suppression items, mechanical items, electrical items, and other systems. Indicate on the coordination drawings where components will be installed and how the service access area to such items shall be maintained. Illustrate items requiring access for maintenance or adjustment.

c. The Contractor will not be allowed any time extensions for participation in the coordination drawing process. The Contractor will not be allowed any contract cost extra for any additional fittings, rerouting or changes of duct size to equivalent sizes to those shown on the drawings that may be determined necessary through the coordination drawing process.

d. Deviations from the contract documents that are necessary for overall system installation and coordination shall be brought to the attention of the Architect/Engineer. Such necessary changes in the contract scope discovered through the coordination drawing process will be covered by the requirements of the "change order" process.

e. Access panels shall occur only in gypsum wallboard or plaster ceilings where indicated on the drawings or as needed to provide access to equipment, dampers, or valves. Access to fire suppression and other items shall be through accessible acoustical ceiling areas. Additional access panels will not be allowed without written approval from the Architect/Engineer at the coordination drawing stage and only after alternatives are reviewed. Layout changes shall be made to avoid additional access panels. If additional access panels are required, they shall be provided at no additional cost to the Owner.

f. Soffit penetrations and light alcoves shall be fully coordinated with hanging devices, studs, fire/smoke ratings, and structural support requirements.

2. Drawings shall be prepared at 1/4 inch = 1 foot, 0 inches (minimum).

a. Coordination participants shall provide equipment installation and clearance requirements. This information shall be indicated on the coordination drawings.

b. Coordination drawings shall indicate the following major system components (including insulation, hub or connection widths with verification of turning radius):

1) Roof drain leaders
2) Large waste piping
3) Sprinkler mains
4) Equipment located above the ceiling
5) Heating hot water piping
6) Chilled water piping
7) Conduit runs 2 inches and larger
8) Cable tray
9) Bus duct
10) Recessed light fixtures
11) Building wiring or cable trays
12) Ceiling heights as shown in contract documents and thickness of system
13) Soffits (including framing of supports)
14) Access points and clearances required
15) Access panels
16) Valves
17) Dampers
18) Coils
19) Ductwork
20) Fire-rated wall, partition, and floor penetrations
21) Steam and condensate piping
22) Space allotted for future utilities
23) Equipment in mechanical and electrical spaces

c. Information shall be delineated to indicate distances from column centerlines, pipe/equipment size, and distance from finished floor to bottom of pipe/equipment and hangers.

3. The coordination drawings shall be submitted to the Architect/Engineer and Owner's representative for review. The submitted coordination drawings shall indicate which contractors participated in the process and where conflicts appear to occur even after the priority ranking of utility routing has been utilized. In the event that conflicts require input from the Architect/Engineer, recommended solutions will be provided with the coordination drawings for review by the Architect/Engineer. The Architect/Engineer will review and return an opinion to the contractors for implementation. All contractors shall agree to the final coordinated layout by signing off on the coordination drawings before any construction can begin.

4. Maintain an updated set of coordination drawings at the job site reflecting changes, modifications and adjustments. Changes shall be reflected and sets or new sheets reissued to the Architect/Engineer and the Owner for review on a monthly basis with changes "clouded" and brought to the attention of the Architect/Engineer and the Owner.

5. When a change order request is issued, the affected subcontractors shall review the coordination drawings and bring to the attention of the Contractor and the Architect/Engineer revisions necessary to the work of others not directly affected by the change order.

6. Contractors that fail to cooperate in the coordination drawing effort shall be responsible for all costs incurred for adjustments to the work made necessary to accommodate installations. Provide adequate clearance and access through accessible ceilings. Conflicts that result after the coordination drawings are signed off will be the responsibility of the Contractor or subcontractor who did not properly identify their work or installed the work improperly.

1.10 SUBSTITUTES

A. All proposals shall be based on providing and installing the materials or items of equipment which are hereinafter specified. The Contractor's options in selecting materials and equipment are limited by requirements of the Contract Documents and governing regulations. They are not controlled by industry traditions or procedures experienced by the Contractor on previous construction projects.

B. Equipment Selection: Equipment of greater or larger power, dimensions, capacities, and ratings may be furnished provided such proposed equipment is approved in writing. Associated fire suppression and electrical services, circuit breakers, conduit, motors, bases, and equipment spaces are to be increased accordingly, but all recommended manufacturer clearances, etc., are to be maintained within the allotted fire suppression spaces. No additional costs will be approved for these increases, if larger equipment is approved. If minimum energy ratings or efficiencies of the equipment are specified, the equipment must meet the design requirements and commissioning requirements.

C. Where the terms "or equivalent" is used, the Contractor may substitute alternate equipment, materials, etc. subject to review by the Architect/Engineer and the Owner's representative during the submittal phase of the project.

D. Where the term "or approved equivalent" is used, the Contractor may not substitute alternate equipment, materials, etc. unless requesting approval at least ten (10) days before the bid date. Notifications of any such approvals by the Architect/Engineer shall only be made in writing by Addendum.

E. Where the term "no equivalent" is used, the Contractor must provide the specified or scheduled equipment, materials, etc.

F. Final determination regarding substitutions shall be by the Architect/Engineer.

1.11 WARRANTY

A. Refer to the General Conditions section of this Specification for general warranty requirements and information. Additional warranty requirements are specified in subsequent Fire Suppression Sections.

1.12 CLOSE OUT AND OPERATION INSTRUCTIONS

A. Operate each system and item of equipment in a test run of appropriate duration, but no less than 7 days, to demonstrate sustained, satisfactory performance. Adjust and correct operations as required for proper performance.

B. Systems shall not be used for temporary operation during construction without written approval from the Architect/Engineer and the Authority Having Jurisdiction. If approved and used during construction, all systems must be properly maintained and operated according to manufacturer recommendations. Immediately prior to turnover to the Owner, the contractor shall perform all necessary preventative maintenance according to all manufacturer recommendations.

C. Any system placed in temporary operation for testing during construction shall be properly maintained and operated by the Contractor.

D. All systems shall be protected against freezing, flooding, corrosion or other forms of damage prior to acceptance by the Owner.

E. Material or equipment damaged, shown to be defective or not in accordance with the Specifications shall be repaired or replaced to the satisfaction of the Owner's representative.

F. All tests shall be made after notification to and in the presence of the Owner's representative.

G. Before starting up any system, each piece of equipment comprising any part of the system shall be checked for proper lubrication and any other condition which may cause damage to the equipment or endanger personnel.

H. After systems have been demonstrated to be satisfactory for 7 consecutive days and ready for permanent operation, all permanent pipe line strainers shall be cleaned, valve and packings properly adjusted, lubrication checked and replenished if required. Temporary piping, etc. shall be removed and openings restored in a permanent manner acceptable to the Owner's representative.

I. Conduct a walk-through instruction seminar for the Owner's personnel pertaining to the continued operation and maintenance of fire suppression equipment and systems. Explain the identification system, maintenance requirements, operational diagrams, temperature control provisions, sequencing requirements, security, safety, efficiency and similar features of the systems. Walk through must be documented as to those attending and subjects covered. Walk through document(s) shall be signed and dated by the contractor's representative and the owner's representative.

1. Training sessions shall be recorded by video camera by the contractor and the recording shall be turned over to the owner in DVD format.

J. At the time of substantial project completion, turn over the prime responsibility for operation of the fire suppression equipment and systems to the Owner's operating personnel. Until the time of final acceptance, provide full time operating personnel, who are completely familiar with the work, to consult with and continue training the Owner's personnel.

1. If any systems are operated prior to substantial completion, the contractor shall perform all necessary preventative maintenance according to all manufacturer recommendations.

1.13 RECORD DOCUMENTS

A. Prepare as-built documents in accordance with the requirements in Division 1 Section "PROJECT CLOSEOUT." In addition to the requirements specified in above, indicate the following installed conditions:

1. The Fire Suppression Contractor shall provide the Owner with as-built drawings for pipe mains and branches, size and location, for both exterior and interior; locations of control valves and supervisory switches; drain valves; and indicate all devices requiring periodic maintenance or repair.
2. All fire suppression systems as described in the Specifications and/or shown on the drawings.
3. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located. Valve location diagrams, complete with valve tag chart. Refer to Division 21 Section "Fire Suppression Identification." Indicate actual inverts and horizontal locations of underground piping.

4. Equipment/material locations (exposed and concealed), dimensioned from prominent building lines.
5. All items must be dimensioned in horizontal and vertical plans to allow Architect/Engineer to update Building Information Model (BIM) file for Owner.

1.14 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1 Section "PROJECT CLOSEOUT." In addition to the requirements specified in Division 1, include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. Servicing instructions and lubrication charts and schedules.

B. Provide electronic copies, preferably in Adobe Acrobat Portable Document Format (pdf), of all maintenance manuals to Temperature Control Contractor for use in EMCS front-end system. Provide data in file types compatible with EMCS.

2. PRODUCTS (NOT APPLICABLE).

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 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.

3.2 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

B. Store and handle material and equipment in compliance with manufacturers' recommendations to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

C. Use proper lifting equipment where size/weight requires handling by such means.

D. Comply with manufacturer's rigging and moving instructions for unloading material and equipment, and moving them to final location.

E. Equipment requiring disassembly for access purposes shall be disassembled and reassembled as required for movement into the final location following manufacturer's written instructions.

F. Deliver material and equipment as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

G. Fire Suppression Contractor shall schedule deliveries so as to minimize space and time requirements for storage of materials and equipment on site.

H. Any material that is damaged during delivery, storage, handling, or installation shall be brought to the attention of the Architect/Engineer for review of its acceptability in the project.

1. The Architect/Engineer shall be the sole and final judge as to the suitability of damaged items.

3.3 ROUGH-IN

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

B. Refer to equipment specifications in Divisions 2 through 26 for rough-in requirements.

3.4 COORDINATION

A. Sequence, coordinate, and integrate installations of fire suppression materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.

B. Coordinate the fire suppression work with work of the different trades so that:

1. Interferences between fire suppression, mechanical, electrical, architectural, and structural work, including existing services, will be avoided.

2. Within the limits indicated on the drawings, the maximum practicable space for operation, maintenance repair, removal and testing of fire suppression and other equipment will be provided.
3. 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. Equipment requiring access, including terminal units, fire/smoke dampers, and piping valves.
    d. Ductwork.
    e. Electrical busduct.
    f. Electrical cable trays, including access space.
    g. Piping (hydronic and plumbing).
    h. Sprinkler/standpipe piping.
    i. Electrical conduits and wireway.

4. Pipes, ducts, and similar items, shall be kept as close as possible to ceiling, walls, and columns, to take up a minimum amount of space. Pipes, ducts, and similar items shall be located so that they will not interfere with the intended use of other equipment.

C. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components as they are constructed.

D. Furnish and install, without additional expense to the Owner, all offsets, fittings and similar items necessary in order to accomplish the requirements of coordination.

3.5 FIRE SUPPRESSION INSTALLATIONS

A. All dimensions and clearances affecting the installation of work shall be verified in the field in relation to established datum, to building openings and to the work of other trades.

B. The location of all equipment and systems shall be coordinated to preclude interferences with other construction.

C. Should interferences occur which will necessitate deviations from layout or dimensions shown on the Drawings, the Architect/Engineer and the Owner's representative shall be notified and any changes approved before proceeding with the work.

D. Arrange for chases, slots, and openings in other building components during progress of construction to allow for fire suppression installations.

E. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum possible headroom.

F. Coordinate connection of fire suppression systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

G. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect/Engineer.

H. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

I. Install fire suppression equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.

J. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

K. Welding, sweating, or brazing operations

1. All cutting, welding, brazing, or sweating operations carried on in the vicinity of, or accessible to, combustible material shall be adequately protected to make certain that a spark or hot slag does not reach the combustible material and start a fire.
2. When it is necessary to do cutting, welding, brazing, or sweating close to wood construction, in pipe shafts, or other locations where combustible materials cannot be removed or adequately protected, employ fireproof blankets and proper fire extinguishers. Position another individual nearby to guard against sparks and fire.
3. Whenever combustible material has been exposed to molten metal or hot slag from welding or cutting operations, or spatter from electric arc operations, a guard shall be kept at the place of work for at least one hour after completion to verify that smoldering fires have not been started.
4. Whenever welding or cutting operations are carried on in a vertical shaft or where floor openings exist, a fire guard shall be employed to examine all floors below the point of the welding or cutting operation. The fire guard shall be kept on duty for at least one hour after completion to verify that smoldering fires have not been started.
5. Before any work involving cutting, welding, brazing, or sweating operations is started, consult with the Architect/Engineer as to particular safety precautions to be employed on the work.

3.6 ACCESSIBILITY

A. All work shall be installed so as to be accessible for operation, maintenance and repair with particular attention given to locating valves, controls and equipment requiring periodic lubrication, cleaning, adjusting or servicing of any kind.

3.7 LUBRICATION AND TOOLS

A. Provide for each piece of equipment any special tools and a list of such tools required for the operation or adjustment of the equipment and turn over to the Owner's representative prior to final acceptance of the equipment.

3.8 START-UP

A. PIPING SYSTEMS PRESSURE TESTING

1. The following personnel in the order listed shall be considered acceptable witnesses of all piping pressure testing:

   a. Local Authority Having Jurisdiction
   b. Owner's Representative
   c. Mechanical Engineer / Architect
   d. General Contractor's Foreman

2. Removal of pressure charge and associated drain down shall also be witnessed.
3. Fire suppression contractor shall provide a minimum of 24-hour notice to at least one of the above listed parties before commencing any piping systems pressure test.
4. Pressure gauge requirements: Provide recently calibrated gauge with 4" face and a range such that test pressure is between 50% and 100% of gauge range. For example, a gauge with a 15 psig range is acceptable for a 10 psig pressure test, whereas a gauge with a 30 psig range is unacceptable in this application. Gauge resolution shall be suitable for type of testing, system size and test media. Gauge shall have been recently calibrated.
5. All piping pressurizing equipment (i.e., air compressor) shall be disconnected before test is commenced and shall remain disconnected for the entire duration of the test.
6. Entire system shall be properly vented before test is commenced.
7. For specific piping pressure testing requirements and procedures, see applicable piping systems specification sections. At minimum, however, pipe systems should be tested at the following pressures and all installed components must be rated at this pressure at the actual operating temperature:

   a. Sprinkler and/or standpipe piping 200 psig

8. Submit completed "Pipe Pressure Test Log" provided at the end of this Section for each pressure test before final project closeout. Test log shall also be included in operation and maintenance manuals.

NOTE: USE MULTIPLE FORMS IF NECESSARY

3.9 GENERAL CONTRACTOR - FIRE SUPPRESSION EXTENT OF WORK

A. Access Panels

1. Furnish and install panels for access to all valves and flow switches and similar items where no other means of access, such as readily removable, sectional ceiling is shown or specified.
2. The plans indicate the location of all anticipated access panels. The Division 21 Contractor shall make every effort to locate all material and equipment requiring service and maintenance above accessible ceilings or utilize the indicated access panels. Material and equipment requiring service and maintenance that is shown above inaccessible ceilings shall be relocated to accessible or exposed areas whenever possible. When these items are located in exposed areas, the Division 21 Contractor is to verify with the Architect/Engineer that the installation will not affect the aesthetics of the building. However, when it is not possible to locate these items in accessible or exposed areas due to the configuration of the actual installation of the fire suppression and other trade systems or aesthetic reasons, additional access panels shall be provided. The contractor shall be equitably compensated for the additional access panels.
3. Refer to Section 08 31 13 – Access Doors and Panels for specific information on type and size of panels

B. Cutting and Patching

1. General: Perform cutting and patching in accordance with Division 1 Section "CUTTING AND PATCHING." In addition to the requirements specified in Division 1, the following requirements apply:
2. The Division 21 Contractor shall coordinate all cutting and patching of holes, in existing building and new construction which are required for the passage of fire suppression work.
3. Division 21 Contractor is to notify the General Contractor prior to submitting his bid, the number, size and location of all cutting and patching requirements. The Division 21 Contractor shall be liable for all associated costs of cutting and patching for fire suppression work upon failure to notify the General Contractor prior to bid submission.
4. Under no circumstances shall any structural members, load-bearing walls or footings be cut without first obtaining written permission from the Engineer.
5. Cut, channel, chase and core drill floors, walls, partitions, ceilings, and other surfaces necessary for fire suppression installations. Perform cutting by skilled mechanics of the trades involved.
6. Patching of concrete openings shall be filled with grout and finished smooth with the adjacent surface.
7. All below-grade openings for pipe shall be sealed with interlocking synthetic rubber line assembly, Link-Seal by Thunderline Corporation or equal.
8. **All penetrations through the walls, floor, or structure of laboratory spaces, laboratory support spaces, corridors or other areas in which relative pressurization relationships are important shall be sealed airtight. Refer to the drawings for additional information regarding rooms in which maintaining pressurization is important.**

9. Repair cut surfaces to match adjacent surfaces.
10. Perform cutting, fitting, and patching of fire suppression equipment and materials required to:

    a. Uncover work to provide for installation of ill-timed work.
    b. Remove and replace defective work.
    c. Remove and replace work not conforming to requirements of the Contract Documents.
    d. Remove samples of installed Work as specified for testing.
    e. Install equipment and materials in existing structures.
    f. Upon written instructions from the Architect, uncover and restore Work to provide for Architect/Engineer observation of concealed Work.

C. Excavation and Backfilling

1. Division 21 Contractor shall perform all excavation and backfilling necessary to install the required fire suppression work. Coordinate the work with other excavating and backfilling work in the same area.
2. Except as indicated otherwise, comply with the applicable sections in Division 2 of these specifications, excavation filling and backfilling (for structures) to 5' outside the building line, and exterior utilities sections for beyond 5' from the building line.
3. Trenching: Trench width shall be no more than required for shoring, bracing and performance of the work. All necessary shoring and bracing shall be installed to insure worker safety, proper installation of fire suppression work, and protection of adjacent structures. Provide all dewatering as required. Depth shall not exceed that required to achieve the specified depth of cover and overdig will be permitted for bedding material only. All trenches shall be open cut from the surface.
4. Bedding: All work shall be properly bedded whether on virgin soil or on granular bedding as specified. All granular bedding shall be laid on undisturbed soil. PVC and copper piping shall have a 4" crushed stone bed conforming to specification for granular material in Division 2. If rock is encountered, excavate to a point 4" below installed bottom elevation of piping and provide bedding as called for above.
5. Haunching: Haunching shall be brought up on both sides of the pipe for a distance of 1/3 the pipe diameter and shall be of the same material used for bedding.
6. Backfill: Backfilling shall not begin until installation has been tested for leaks.
7. Final Backfill shall be as follows:

    a. Outside Building Under Paved Areas: Granular material specified in Division 2.
    b. Outside Building and Not Under Paved Areas: Clean soil free of vegetable matter and foreign material or crushed limestone. In planted areas backfill to a point 6" below finished grade. Owner will provide topsoil to finished grade.

8. Placement: Place all granular material in lifts of 12" maximum compacted to 100% of maximum dry density as determined as ASTM D698. Place soil in 6" lifts compacted to 95% of maximum density as determined by ASTM D698. Do not place any backfill until excavations have been cleaned of all water, debris and loose or soft soil.

9. Protection: At least 72 hours prior to excavating, for each phase, Contractor shall contact the Owner's Representative to arrange for utility locates in the construction area.
10. Contractor shall provide temporary supports for all underground utilities crossing an excavation.
11. Provide all required barricades, fencing, signs, lights, etc. as necessary for the protection of the workers and of the general public.
12. Excess Material: All excess earth and other material resulting from the excavation shall be removed from site daily by the Contractor.
13. Landscape work, pavement, flooring and similar exposed finish work that is disturbed or damaged by excavation shall be repaired and restored to their original condition by the Fire Suppression Contractor.

D. Concrete Bases

1. Minimum 4" high concrete housekeeping pads shall be provided under all floor-mounted fire suppression equipment, regardless of whether explicitly shown on the Drawings. Concrete inertia pads with spring isolators shall be provided for all base-mounted pumps and air compressors installed on any floors which are not slab-on-grade. Inertia pads and isolators shall be sized by the equipment manufacturer if specific information is not provided in the Contract Documents.
2. Division 21 Contractor is to notify the General Contractor prior to submitting his bid, the number, size and location of all fire suppression equipment bases. The Division 21 Contractor shall be liable for all associated costs to install the fire suppression equipment bases upon failure to notify the General Contractor prior to bid submission.
3. Construct concrete equipment bases a minimum 4 inches larger in both directions than supported unit. Follow supported equipment manufacturer's setting templates for anchor bolt and tie locations. Use 3000 psi, 28-day compressive strength concrete, reinforcement and forms as specified in Division 3 Section "Cast-In-Place Concrete." Coordinate final equipment base size with General Contractor.
4. All equipment shall be mechanically fastened to concrete bases.

E. Roof curbs, roof support for fire suppression equipment and roof penetrations.

1. Verify, prior to submitting bid, the number, size, and location of all roof curb and roof supports and the location of all roof penetrations. Provide all roof deck-mounted equipment, pipe supports, and pipe penetrations. Cut roof deck for pipe and duct penetrations, unless noted otherwise. Provide all roof covering/membrane mounted equipment and pipe supports and roof drains, unless noted otherwise.
2. Contractor shall be liable for all associated costs to install the roof curbs, roof supports and roof penetrations not shown on the roof plan or added after the roof system has been installed. Coordinate with the General Contractor prior to construction the number size and location of all roof penetrations.
3. All roof curbs, supports, and rails shall be sized to keep equipment a minimum of 24” above the roof insulation membrane in order to limit snow accumulation at or near equipment.

F. Painting

1. The General Contractor is to field paint fire suppression equipment and materials in specified areas as noted on the fire suppression plans, fire suppression schedules and in the specifications. Division 21 Contractor is to coordinate the painting of these items with the General Contractor. The Fire Suppression Contractor is to provide materials in these areas that are suitable for accepting paint. The clean and preparation of the materials to reach paint is the responsibility of the General Contractor unless noted specifically to be responsibility of the Division 21 Contractor.
2. In concealed locations, field-fabricated bare iron or steel items required for installation of work under this Division shall have rough or sharp edges removed and shall be painted with one coat of zinc rich paint.
3. In exposed locations, field-fabricated bare iron or steel items required for installation of work under this Division shall have rough or sharp edges removed and shall be painted in accordance with Section 09 91 00.

3.10 ELECTRICAL-FIRE SUPPRESSION EXTENT OF WORK

A. The responsibility of work specified under Division 21 and 26 is clarified under Section 21 05 13, "Electrical Requirements for Fire Suppression Equipment. Division 21 Contractor is to coordinate all electrical requirements prior to ordering powered fire suppression equipment.

END OF SECTION 21 05 00

PIPE PRESSURE TEST LOG

PROJECT:

BUILDING:

GENERAL CONTRACTOR:

CLARK ENERSEN PROJECT NUMBER:

MECHANICAL CONTRACTOR:

TEST INFORMATION						TEST PRESSURE					
TEST DATE	PIPING SYSTEM	AREA TESTED	TEST MEDIA (WATER OR AIR)	TEST DURATION (MINUTES)	PRESSURE GAGE NUMBER	INITIAL (PSIG)	FINAL (PSIG)	TESTED BY	WITNESSED BY	PASS / FAIL (P/F)	COMMENTS

ADDITIONAL COMMENTS:

PRESSURE GAGE INFORMATION

GAGE NUMBER	MANUFACTURER	PRESSURE RANGE	RESOLUTION	STYLE	DIAL SIZE	GAGE NUMBER	MANUFACTURER	PRESSURE RANGE	RESOLUTION	STYLE	DIAL SIZE

NOTE: USE MULTIPLE FORMS IF NECESSARY

SECTION 21 05 13 - ELECTRICAL REQUIREMENTS FOR FIRE SUPPRESSION EQUIPMENT

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section.

B. Related Sections: Separate electrical components and materials required for field installation and electrical connections are specified in Division 26.

1.2 SUMMARY

A. This section specifies the basic requirements for electrical components which are an integral part of packaged fire suppression equipment. These components include, but are not limited to factory installed motors, starters, and disconnect switches furnished as an integral part of packaged fire suppression equipment. In addition, this section covers necessary coordination issues between fire suppression and electrical disciplines. All fire suppression and electrical construction documents must be completely reviewed by the Fire Suppression and Electrical Contractors prior to the submission of bids. Any discrepancies in the documents should be brought to the Architect/Engineer's attention at that time. Failure to properly coordinate or review documents in advance of submission of bids will not be valid cause for changes to the overall Contract amount.

B. Specific electrical requirements (i.e. horsepower and electrical characteristics) for fire suppression equipment are scheduled on the Drawings.

1.3 REFERENCES

A. The design, manufacture, testing and method of installation of all equipment and materials furnished under the requirements of this specification section shall conform to the following:

1. NEMA Standard ICS 2: Industrial Control Devices, Controllers, and Assemblies.
2. NEMA Standard 250: Enclosures for Electrical Equipment.
3. NEMA Standard KS 1: Enclosed Switches.
4. National Electrical Code (NFPA 70).

1.4 SUBMITTALS

A. No separate submittal is required. Submit product data for motors, starters, and other electrical components with submittal data required for the equipment for which it serves, or as required by the individual equipment specification sections.

1.5 QUALITY ASSURANCE

A. Electrical components and materials shall be UL labeled and listed.

2. PRODUCTS

2.1 MOTORS

A. The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications.

1. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.
2. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range. Minimum service factors shall be as follows:

Motor Service Factor Schedule		
Horsepower:	**3600 RPM:**	**1800 RPM:**
1/6 – 1/3	1.35	1.35
1/2	1.25	1.25
3/4	1.25	1.25
1 – 1.25	1.25	1.15
1.5 - 150	1.15	1.15

3. Two-speed poly-phase motors shall have two separate windings served by a single point electrical connection to the two speed starter. Two speed starters shall be located at the motor location unless otherwise noted.
4. Temperature Rating: Rated for 40 deg. C environment with maximum 50 deg. C temperature rise for continuous duty at full load (Class A Insulation).
5. Starting capability: Frequency of starts as indicated by automatic control system, and not less than five (5) evenly timed starts per hour for manually controlled motors.
6. Motor construction: NEMA Standard MG 1, general purpose, continuous duty, Design "B", except "C" where required for high starting torque.

a. Frames: NEMA Standard No. 48 or 54; use driven equipment manufacturer's standards to suit each specific application.
b. Bearings: Ball or roller bearings with inner and outer shaft seals; regreasable; designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor; for fractional horsepower, light duty motors, sleeve type bearings are permitted.
c. Enclosure Type: Unless otherwise indicated, open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation; guarded

drip-proof motors where exposed to contact by employees or building occupants; weather protected Type I for outdoor use, Type II where not housed.

d. Overload protection: Built-in thermal overload protection (in accordance with NEC requirements) and, where indicated, an internal sensing device suitable for signaling and stopping the motor at the starter.

7. Noise rating: "Quiet"
8. Efficiency: "Premium efficiency" motors, as defined in NEMA MG 1, most recent edition.
9. Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.
10. Motors Used With Variable Frequency Drives: Ratings, characteristics, and features coordinated with and approved by drive manufacturer. Motor shall be designed and labeled for use with variable frequency drives. Motor shall be designed with critical vibration frequencies outside the operating range of the drive output and shall be suitable for use throughout speed range without overheating.

a. Provide AEGIS SGR, or approved equivalent, shaft grounding ring/system to divert adverse shaft currents away from the motor bearings. Use AEGIS Colloidal Silver Shaft Coating (PN CS015), or approved equivalent, prior to ring installation. Install coating and ring per manufacturer recommendations.

2.2 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 shall be responsible for replacement sheaves required to achieve specified performance. Coordinate with testing and balancing of the equipment.

2.3 STARTERS, ELECTRICAL DEVICES, AND WIRING

A. Motor-Starter Characteristics: Motor starters shall be compatible with the equipment they serve. In general, motor starter characteristics shall meet the requirements of Division 26 specification sections

B. MOTOR CONNECTIONS

1. Provide connections to motors in accordance with the requirements listed in the electrical specifications.
2. See Division 26 for the use of lugs for motor connections.

2.4 SAFETY SWITCHES

A. Furnish and install heavy duty type safety switches, having the electrical characteristics, ratings and modifications shown on the drawings. All switches shall have:

1. NEMA 1 general purpose enclosures unless otherwise noted for all interior applications.
2. NEMA 3R rainproof enclosures unless otherwise noted for all exterior applications.
3. Metal nameplates, front cover mounted that contain a permanent record of switch type, catalog number and H.P. ratings with both standard and time delay fuses.
4. Handle that is padlockable in "OFF" position.
5. Non-teasible, positive quick-make, quick-break mechanism.
6. UL approval and shall bear the UL label.
7. All fusible switches shall have Class R Fuse rejection clips.

2.5 DIVISION-26 RESPONSIBILITY

A. Unless otherwise noted, furnish and install single phase starters with thermal overload protection for all single phase motors not indicated as part of the Division 21 responsibility. Furnish and install all full voltage, non-reversing, single speed motor starters for appropriate three phase equipment. Furnish and install disconnect switches for all three phase motors. Provide the following additional equipment as required.

B. Provide auxiliary motor starter contacts as shown on the drawings or as required for proper control of equipment.

C. Furnish and install all motor power circuit conduit and wiring.

D. Install power factor correction capacitors furnished by the Division 21 Contractor.

E. Furnish and install all junction boxes.

2.6 DIVISION-21 RESPONSIBILITY

A. Furnish and set all motors.

B. Furnish and install all electrical control circuit conduits and wiring and control devices required to perform the equipment control functions as specified in Division-21.

C. All electrical equipment provided, including the wiring and installation of electrical equipment shall be in strict accordance with the requirements of this Section and Division-26.

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.

3.2 CONTRACTOR COORDINATION

A. Unless otherwise indicated on drawings, all equipment, controls, etc. shall be furnished, set in place and wired in accordance with this specification section and the following schedule. Attached notes shall apply to schedule.

ITEM:	FURNISHED BY:	SET BY:	POWER WIRING BY:	TEMPERATURE CONTROL WIRING BY:
Fire suppression solenoid valves, supervisory switches, etc.	FPC	FPC	EC	--

SCHEDULE KEY: FPC = Fire Suppression Contractor
EC = Electrical Contractor

END OF SECTION

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SECTION 21 05 19 – FIRE SUPPRESSION GAUGES

1. GENERAL

1.1 SECTION INCLUDES

A. Pressure gauges and pressure gauge taps.

B. Piping pressure and temperature test plugs.

1.2 REFERENCE SECTION 21 05 00 FOR THE FOLLOWING:

A. REFERENCES

B. SUBMITTALS

C. PROJECT RECORD DOCUMENTS

1. Accurately record actual locations of instrumentation.

1.3 ENVIRONMENTAL REQUIREMENTS

A. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

2. PRODUCTS

2.1 PRESSURE GAUGES

A. Type: General use, ASME B40.1, Grade A, phosphor bronze bourdon-tube type, bottom connection, liquid-filled.

B. Case: Drawn steel or brass, glass lens, 4-1/2-inches diameter.

C. Connector: Brass, 1/4-inch NPS.

D. Scale: White coated aluminum, with permanently etched markings.

E. Accuracy: Plus or minus 1 percent of range span.

F. Range: Conform to the following:

1. Vacuum: 30 inches Hg to 15 psi.
2. All fluids: 2 times operating pressure.

2.2 PRESSURE GAUGE ACCESSORIES

A. Syphon: 1/4-inch NPS straight coil constructed of brass tubing with threads on each end.

B. Snubber: 1/4-inch NPS brass bushing with corrosion-resistant porous metal disc. Disc material shall be suitable for fluid served and rated pressure.

2.3 PIPING PRESSURE AND TEMPERATURE TEST PLUGS

A. Test Plugs shall be nickel-plated brass body, with 1/2-inch NPS fitting and 2 self-sealing valve-type core inserts, suitable for inserting a 1/8-inch O.D. probe assembly from a dial-type thermometer or pressure gage. Test plug shall have gasketed and threaded cap with retention chain and body of length to extend beyond insulation. Pressure rating shall be 500 psig.

B. Core Material: Conform to the following for fluid and temperature range:

1. Air, Water, Oil, and Gas, 20 to 200 deg F: Neoprene.

3. EXECUTION

3.1 GENERAL

A. Install in accordance with manufacturer's instructions and NFPA 13 and NFPA 14 requirements.

3.2 PRESSURE GAUGES

A. Install pressure gauges in piping tee with pressure gauge valve, located on pipe at most readable position.

B. Install as shown on plans, and elsewhere as indicated.

C. Pressure Gauge Ball Valves: Install in piping tee with snubber. Install syphon in lieu of snubber for steam pressure gages.

3.3 TEST PLUGS

A. Test Plugs: Install where indicated, located on pipe at most readable position. Secure cap.

3.4 ADJUSTING AND CLEANING

A. Adjusting: Adjust faces of meters and gauges to proper angle for best visibility.

B. Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touch-up paint.

END OF SECTION

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SECTION 21 05 29 – FIRE SUPPRESSION HANGERS AND SUPPORTS

1. GENERAL

1.1 SECTION INCLUDES

A. Pipe and equipment hangers, supports, anchors, saddles and shields.

B. Sleeves and seals.

C. Mechanical sleeve seals.

D. Sealants, firestop insulation, putty and compounds.

1.2 REFERENCE SECTION 21 05 00 FOR THE FOLLOWING:

A. REFERENCES

1. NFPA 13, 14, and 24.
2. MSS SP-58 – Pipe Hangers and Supports – Materials, Design, and Manufacture.
3. MSS SP-69 – Pipe Hangers and Supports – Selection and Application.
4. MSS SP-89 – Pipe Hangers and Supports – Fabrication and Installation Practices.

B. SUBMITTALS

C. DELIVERY, STORAGE, AND HANDLING

2. PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

A. Fire Suppression and Standpipe Piping:

1. Conform to International Fire Code, NFPA 13, NFPA 14, NFPA 24, MSS SP58, MSS SP69 and MSS SP89, as applicable.

B. Hangers and Supports:

1. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch, Carbon steel, adjustable swivel, band type.
2. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
3. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
4. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.

5. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp.
6. Vertical Support: Steel riser clamp.
7. Floor Support for Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
8. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

2.2 ACCESSORIES

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

2.3 INSERTS

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

2.4 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Internally Threaded Screw Anchors: Internally threaded, self tapping screw anchors, Power Fasteners Snake or approved equivalent.

1. Tested in accordance with ACI 355.2 and ICC-ES AC193 for use in structural concrete under the design provisions of ACI318 (Strength Design method using Appendix D)

2.5 SLEEVES

A. Sleeves for Pipes Through Non-fire Rated Floors: 18 gage galvanized steel.

B. Sleeves for Pipes Through Non-fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Steel pipe or 18 gage galvanized steel.

C. Sleeves for Pipes Through Fire Rated and Fire Resistive Floors and Walls, and Fire Proofing: Prefabricated fire rated sleeves including seals, UL listed.

2.6 SEALANTS, FIRESTOP INSULATION, PUTTY, AND COMPOUNDS

A. Firestopping Insulation: Glass fiber type, non-combustible, UL listed.

B. Firestop Putty: Non-harding, non shrinking, UL listed.

C. Firestop Compounds: Cementitous material, non-shrinking, UL listed.

D. Sealants:

1. Non fire/smoke rated partitions: Acrylic or silicone based caulking.
2. Fire/smoke rated partitions: Silicone based caulking, UL listed.

2.7 MECHANICAL SEALS

A. Mechanical Seals: Modular mechanical type, consisting of interlocking EPDM synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with type 316 stainless steel bolts and reinforced plastic polymer pressure plates which cause rubber sealing elements to expand when tightened, providing a watertight and gas-tight seal and electrical insulation. Provide Advance Products & Systems Model Innerlynx or equivalent.

1. A sleeve shall be provided for each mechanical seal.

a. Thermoplastic sleeves: Sleeve shall have smooth walls and shall be made of molded non-metallic high density polyethylene (HDPE) with an integral solid water stop, Advance Products & Systems Model PWS or equivalent.
b. Steel sleeves: Sleeve shall have smooth walls, shall be made of Schedule 40 steel with an integral welded solid water stop, and shall have corrosion-resistant coating, Advance Products & Systems Model GWS or equivalent.

3. EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NFPA 13, 14, and 24.

3.2 INSERTS

A. Provide inserts for placement in concrete formwork.

B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.

D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

E. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.3 PIPE HANGERS AND SUPPORTS

A. Support horizontal piping as scheduled.

B. Support fire suppression systems piping independently from other piping systems. Fire main piping may be trapezed with other piping systems. Coordinate trapeze hangers with the Division 21 Contractor and other trades.

C. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.

D. Place hangers within 12 inches of each horizontal elbow.

E. Use hangers with 1-1/2 inch minimum vertical adjustment.

F. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.

G. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.

H. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

I. Support riser piping independently of connected horizontal piping.

J. Provide copper plated hangers and supports for non-insulated copper pipe.

K. Design hangers for pipe movement without disengagement of supported pipe.

L. Prime coat steel hangers and supports in the mechanical room and other exposed areas. Refer to the Architectural reflected ceiling plans for location of exposed ceilings. Hangers and supports located in attic space, crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

M. Adjust hangers to distribute loads equally on attachments and to achieve specified pipe slopes.

3.4 FLASHING

A. Provide flexible flashing and metal counterflashing where piping penetrate weather or waterproofed walls and floors.

B. Provide acoustical lead flashing around pipes penetrating equipment rooms, installed in accordance with manufacturer's instructions for sound control.

3.5 SLEEVES

A. Provide pipe and duct sleeves at all fire/smoke rated partitions, exterior wall penetrations and wall penetrations into exposed areas. Pipe sleeves are not required for penetrations through non-rated concealed partitions.

B. At the Contractor's option, pipe sleeves may be omitted if the wall or floor is core drilled, except in areas potentially exposed to wet conditions (such as mechanical rooms, loading dock, generator room, penthouse, kitchen, etc.).

C. Set sleeves in position in formwork. Provide reinforcing around sleeves.

D. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.

E. Sleeves through floors shall be grinded flush with finish floor level. In areas potentially exposed to wet conditions (such as mechanical rooms, loading dock, generator room, penthouse, kitchen, etc.), sleeve shall extend a minimum of 2" above finish floor.

F. Where piping penetrates non-rated ceilings or walls, close off space between pipe and adjacent work with urethane rod stock and caulk air tight.

G. Seal pipe penetrations through non-rated floors.

1. Where piping is not located in a rated shaft and it penetrates a single non-rated floor, close off space between pipe and adjacent work with urethane rod stock and caulk air tight.
2. Where piping is not located in a rated shaft and it penetrates multiple non-rated floors, close off space between pipe and adjacent work with appropriate fire-rated sealant, insulation, putty, or compound.

H. Where piping penetrates rated floor, ceiling, or wall, close off space between pipe or duct with appropriate fire rated sealant, insulation, putty or compound. Refer to the Drawings for fire/smoke rated wall locations and the appropriate ratings.

I. Install chrome plated steel escutcheons on piping at finished surfaces.

J. Provide mechanical seals and sleeves through exterior wall and floor penetrations and 3 hour or higher fire rated partitions.

3.6 HANGER SCHEDULES

A. Reference International Fire Code, NFPA 13, and NFPA 14 where applicable.

END OF SECTION

SECTION 21 05 53 – FIRE SUPPRESSION IDENTIFICATION

1. GENERAL

1.1 SECTION INCLUDES

A. Nameplates.

B. Tags.

C. Pipe Markers.

D. Ceiling Tacks/Stickers.

1.2 REFERENCE SECTION 21 05 00 FOR THE FOLLOWING:

A. REFERENCES

B. RELATED SECTIONS

C. SUBMITTALS

D. QUALITY ASSURANCE

E. PROJECT RECORD DOCUMENTS

1. Record actual locations of tagged valves.

2. PRODUCTS

2.1 NAMEPLATES

A. Equipment Mark Nameplates: Laminated three-layer plastic with engraved black letters (matching equipment mark indicated on drawings) on light contrasting background color, with minimum 3/4 inch high letters.

B. Equipment Nameplates: Factory-applied permanent nameplate indicating the manufacturer's name, model, serial number, temperature and pressure design, and any other data necessary to conform with specified requirements. On equipment installed outdoors, nameplate shall be stamped steel or engrave plastic.

2.2 TAGS

A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter or square.

B. Chart: Typewritten list that is plastic laminated and mounted in mechanical room. Valve list is to coordinate with mechanical piping schematics if provided on plans.

C. Pipe Schematics: Valve numbers are to be labeled on Engineer schematic drawings, plastic laminated and schematic shall be mounted in mechanical room.

2.3 PIPE MARKERS

A. Color: Conform to ASME A13.1.

B. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings; minimum information indicating flow direction arrow and identification of fluid being conveyed.

3. EXECUTION

3.1 PREPARATION

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

3.2 INSTALLATION

A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

B. Install tags with corrosion resistant chain.

C. Install plastic tape pipe in accordance with manufacturer's instructions. Directional arrow tape shall be overlapped to ensure proper adhesion and no peeling of tape in future.

D. Identify hose connections cabinets and drain termination points with plastic nameplates.

E. Identify tags on backflow preventers, drain valves, test connections, risers, alarm devices, and hose connections with tags. Label each valve as normally open or normally closed, as appropriate.

F. Identify valves in main and branch piping with tags.

G. Identify piping, concealed or exposed, with plastic tape pipe markers. For pipes ¾" and smaller, identify piping with tags. Identify service, flow direction, and pressure when applicable, i.e. low pressure steam, high pressure steam. Install in clear view from floor and align with axis of piping. Locate identification not to exceed 15 feet on straight runs including risers and drops, more often in congested areas, adjacent to each valve and tee, at each side of penetration of structure or enclosure, and at each obstruction. Provide a minimum one label per pipe per room. Where pipes are racked, install pipe markers on each pipe in the same location to aid in differentiating each pipe in the rack.

END OF SECTION

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SECTION 21 13 13 - FIRE SUPPRESSION SYSTEM

1. GENERAL

1.1 SECTION INCLUDES

A. Pipe, fittings, valves, and connections for an automatic wet-pipe sprinkler system.

B. System design, installation, and certification.

C. Water main connections.

1.2 REFERENCE SECTION 21 05 00 FOR THE FOLLOWING:

A. REFERENCES

1. NFPA 13 - Installation of Sprinkler Systems.
2. NFPA 24 - Installation of Private Fire Service Mains and Their Appurtenances

B. PROJECT RECORD DOCUMENTS

1. Record actual locations of sprinklers and deviations of piping from drawings. Indicate drain and test locations.

C. OPERATION AND MAINTENANCE DATA

D. DELIVERY, STORAGE, AND HANDLING

1. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

1.3 SYSTEM DESCRIPTION

A. System to provide coverage for the entire building to include overhangs as required by NFPA.

B. System shall be an automatic wet sprinkler system conforming to NFPA 13 Light Hazard, Ordinary Hazard – Group 1, and Ordinary Hazard – Group 2 occupancy requirements. See drawings for zoning requirements and additional information.

C. Determine volume and pressure of incoming water supply from water flow test data. Obtain water flow test data from Owner's Representative. See drawings for further information.

D. Interface system with building fire and smoke alarm system. Fire alarm specialties related to the sprinkler system (i.e. flow switches, supervisory valves, etc.) shall be provided and installed by the sprinkler contractor. However, these devices shall be wired under Division 26.

E. Although not specifically specified, the Contractor shall provide and install all supplementary and/or miscellaneous items and devices as required for a complete, code compliant and operational sprinkler system.

1.4 SUBMITTALS

A. **Note the following procedure for fire suppression submittals:**

B. Shop Drawings: Indicate hydraulic calculations, detailed pipe layout, hangers and supports, components and accessories. Indicate system controls. Indicate pipe materials used, jointing methods, supports, floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.

C. Product Data: Provide data on sprinkler heads, valves, and specialties, including manufacturer's catalogue information. Submit performance ratings rough-in details, weights, support requirements, and piping connections.

D. Submit shop drawings, product data, hydraulic calculations to Owner and Engineer for approval. After initial submittal has been reviewed by the Owner and Engineer and the review comments have been incorporated, submit all information to the authority having jurisdiction (local and state Fire Marshal) for approval. Coordinate submittal to authority having jurisdiction with the fire alarm shop drawing submittal. Submit proof of approval to Architect/Engineer.

1.5 QUALITY ASSURANCE

A. Designer and Installer: Company specializing in performing work of this Section with minimum three years experience.

B. Sprinkler Systems: Perform work to NFPA 13. Contractor shall hydraulically calculate system pipe sizes in accordance with NFPA 13. Calculations and design drawings shall be sealed by a licensed Professional Engineer registered in Missouri.

C. All grooved fittings, valves, and specialties shall be compatible with the specified coupling.

D. Equipment and Components: Bear UL and FM label or marking.

E. Valves: Bear UL and FM label or marking. Provide manufacturer's name and pressure rating marked on valve body.

1.6 REGULATORY REQUIREMENTS

A. Hydraulic Calculations, Product Data, Shop Drawings: Bear stamp of approval of authority having jurisdiction (including Fire Marshall if required); Shall be sealed by a licensed Professional Engineer registered in Missouri.

1.7 EXTRA MATERIALS

A. Furnish under provisions of appropriate Division 1 specification section.

B. Provide extra sprinklers and storage cabinets under provisions of NFPA 13.

C. Provide suitable wrenches for each head type.

2. PRODUCTS

2.1 SPRINKLER PIPING, BURIED

A. Ductile Iron Pipe: ASTM A377, AWWA C106, Class 150.

1. Fittings: AWWA C110, ductile iron, standard thickness.
2. Joints: Mechanical joints with ANSI/AWWA C111 rubber gasket.

2.2 SPRINKLER PIPING, ABOVE GROUND

A. Steel Pipe: ASTM A53 or ASTM A795; Schedule 40 black steel.

1. Steel Fittings: ANSI/ASME B16.5, steel flanges and fittings.
2. Cast Iron Fittings: ANSI/ASME B16.4, screwed fittings.
3. Malleable Iron Fittings: ANSI/ASME B16.3, screwed type.
4. Joints: Flanged, grooved or threaded.
5. Mechanical Grooved Couplings: Victaulic Installation-Ready 107N and 009-EZ or 005 Firelock Rigid with rolled grooved fittings, no equivalent. Cut grooves or O-ring type socket fittings are not allowed.
6. Mechanical weld-o-lets and thread-o-lets are allowed.
7. Mechanical Tee fittings are not allowed unless approved by the Project Engineer.

B. Pipe hangers shall conform to NFPA standard 13 requirements and shall be FM/UL approved for use in fire sprinkler systems. Refer to specification section 21 05 29 for additional information.

C. Sprinkler piping in exposed animal holding areas shall be coated with epoxy paint for corrosion-resistance. Refer to 09 96 00 – High Performance Coatings.

2.3 FLEXIBLE SPRINKLER HOSE

A. Manufacturer: Victaulic, no equivalent.

B. Basic Use:

1. Flexible stainless-steel hose assemblies and a bracketing system that connect sprinkler heads to the branch lines. Each flexible hose assembly shall be provided with an open-gate mounting bracket and a 1-piece, leak tested sprinkler drop. The mounting bracket shall be compatible with application and allow installation before the ceiling tile is in place.
2. Flexible hose assembly shall be pressure/leak tested system available in 2' – 6' hose lengths.
3. Hose bend radius to 2" for AH2 or AH2-CC, and 3" for AH1.
4. All flexible hose assembly shall Factory Mutual (FM 1637) approved and UL 2443 listed and are manufactured in an FM/UL audited facility.
5. Zinc plated steel Male threaded nipple or Victaulic FireLock IGS Groove Style 108 coupling for connection to branch-line piping.
6. Compatible with any FM/UL approved sprinkler head.
7. 100% leak tested system.
8. Industrial grade, all welded, no O-ring construction, with all stainless steel components.
9. Adjustable height and sprinkler alignment / center-of-tile uniformity.
10. Rated up to 300 psi with no additional hangers required.
11. Approved for use in suspended ceiling systems with light, medium and heavy load grids (ASTM C635, C636)
12. True-bore 1" internal corrugated hose diameter, which produces friction loss values similar to hard pipe armovers.
13. IBC and SEI/ASCE 7-02 compliant for sprinklers installed in seismic design classes C and D/E/F.

C. Composition and Materials:

1. Every flexible hose assembly shall come complete with the flexible hose. Each connection shall be made from 100% factory tested Type 304 stainless steel. The hose nipples shall be 304 stainless steel and be fully welded. Flexible hose assembly shall be leak tested to 175 psi. Hose factory tested to 400 psi (2760 kPa.
2. The bracket system shall be factory or shop fabricated made from galvanized sheet metal and is approved and compatible for application. Coordinate with flexible hose manufacturer.

D. Flexible fire sprinkler hose is not allowed for use in an exposed ceiling, all areas that are visible shall be hard piped.

E. Basis of Design: Victaulic Vic-Flex.

2.4 GATE VALVES

A. Up to and including 2 Inches: Bronze body, bronze trim, non-rising stem, handwheel, inside screw, solid wedge disc, threaded ends, class 175, UL/FM approved.

B. Over 2 Inches: Iron body, bronze trim, rising stem, handwheel, OS&Y, solid wedge disk, flanged or grooved ends, class 175, UL/FM approved.

2.5 ANGLE VALVES

A. Up to 2 Inches: Bronze body, bronze trim, rising stem and handwheel, inside screw, renewable composition disc, screwed ends, with backseating capacity, class 175, UL/FM approved.

B. Over 2 Inches: Iron body, bronze trim, rising stem, handwheel, OS&Y, plug-type disc, flanged ends, renewable seat and disc, class 175, UL/FM approved.

2.6 BALL VALVES

A. Up to and including 2 Inches:

1. Bronze two piece body, stainless steel ball, Teflon seats and stuffing box ring, lever handle threaded ends, blowout proof stem, full port, 600 WOG, UL/FM approved.

2.7 BUTTERFLY VALVES

A. Cast or ductile iron body, aluminum bronze disc, resilient replaceable EPDM seat, grooved, wafer, or lug ends, extended neck handwheel and gear drive and integral indicating device and built-in tamper proof switches, 300-psi rated, UL/FM approved.

2.8 CHECK VALVES

A. Up to and including 2 Inches: Bronze swing disc, screwed ends, class 200, UL/FM approved.

B. Over 2 Inches: Iron body, stainless steel or bronze trim, spring-assisted swing disc for vertical or horizontal installation, renewable disc and seat, flanged, screwed or grooved ends, UL/FM approved.

2.9 SPRINKLER SYSTEM CONTROL VALVES

A. Cast- or ductile-iron body, flanged or grooved ends, 225 psig minimum pressure rating, UL/FM approved.

2.10 DRAIN VALVES

A. Brass ball valve with cap and chain, 3/4 inch hose thread, UL/FM approved.

2.11 PIPING SPECIALTIES

A. Wet Pipe Sprinkler Alarm Valve: Check type valve with divided seat ring, rubber faced clapper to automatically actuate electrically operated alarms, with pressure retard chamber and variable pressure trim. Valve internal components shall be replaceable with valve in the installed position.

B. Water Flow Switch: Electrically supervised vane type switch for mounting horizontal or vertical, with two contacts.

C. Curb stops: Bronze body, ground key plug or ball, wide tee head with inlet and outlet to match service piping. Conform to all local water department requirements.

1. Service box for curb stop: Cast iron box with telescoping top section as required for valve bury depth. Include cover with lettering "WATER," and bottom section with base of size to fit over curb stop and barrel. Conform to all local water department requirements.

D. Tapping sleeve and valve: Complete assembly, including two piece cast iron bolted sleeve with outlet connections suitable for use with size and type of piping being connected.

2.12 FLOW ALARM SWITCHES

A. FM/UL approved, water flow switches which will close contact when flow is detected.

2.13 SPRINKLERS

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating for Automatic Sprinklers: 175 psig minimum.
3. Sprinklers shall be glass bulb type, with hex shaped wrench boss integrally cast into the sprinkler body to reduce the risk of damage during installation. (Wrenches shall be provided by the sprinkler manufacturer that directly engage the cast wrench boss.)

B. Automatic Sprinklers with Heat-Responsive Element:

1. Nonresidential Applications: UL 199.
2. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
3. High or *intermediate* temperature *sprinklers* heads shall be provided in all mechanical rooms, elevator equipment rooms, and emergency generator rooms, attics and elsewhere when elevated ambient temperatures might be expected.

C. Sprinkler Finishes:

1. PTFE (corrosion resistant) in animal areas.

D. Retain special coatings in first paragraph below that are indicated in "Sprinkler Schedule" Article.

E. Special Coatings:

1. Wax.
2. Lead.
3. Corrosion-resistant paint.

F. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Install concealed sprinkler heads in all corridors. Install semi-recessed sprinkler heads in all other spaces with dropped ceilings. Install upright sprinkler heads in all areas without ceilings.

1. Ceiling Mounting: PTFE-coated steel, one piece, flat.
2. Sidewall Mounting: PTFE-coated steel one piece, flat.

A. Sprinkler Guards:

1. Provide sprinkler head guards in mechanical rooms, high traffic areas and areas where heads are lower than 10'- 0" above the finished floor and/or where heads may be vandalized.
2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

G. Escutcheons and guards shall be listed, and supplied for use with the sprinkler by the sprinkler manufacturer.

2.14 VALVE SUPERVISORY SWITCHES

A. Standard: UL 346

B. Type: Electrically supervised

C. Components: Single-pole, double-throw switch with normally closed contacts.

D. Design: Signals that controlled valve is in other than fully open position.

2.15 HOSE CONNECTIONS

A. Connection: UL 668, brass or bronze, 300 psig minimum pressure rating, NPS 2-1/2 hose valve compatible with local fire department requirements, with lugged cap, gasket, and chain. Provide chrome-plated finish.

B. Cabinet: Recessed mounting, 18"x18"x8" fire-rated enclosure, solid panel door with continuous steel piano hinge, white baked acrylic enamel finish, type 304 stainless steel, door and frame materials, with appropriate labeling.

3. EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel, thread or groove plain end ferrous pipe.

B. Remove scale and foreign material, from inside and outside, before assembly.

C. Prepare piping connections to equipment with flanges or unions. Unions and flanges for servicing and disconnect are not required in installations using grooved mechanical joint couplings. (The couplings shall serve as disconnect points if required.)

3.2 INSTALLATION

A. Install piping in accordance with NFPA 13 and NFPA 24 as applicable.

1. Grooved Joints: Install in accordance with the manufacturer's latest published installation instructions. Pipe ends shall be clean and free from indentations, projections and roll marks in the area from pipe end to (and including) groove. Gasket shall be manufactured by the coupling manufacturer and verified as suitable for the intended service. Contractor shall remove and replace any improperly installed products.

B. Provide thrust blocks for each change of direction in underground fire service pipe in accordance with NFPA 24.

C. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient. Place pipe runs to minimize obstruction to other work.

D. Install piping to conserve building space, and not interfere with use of space and other work. It shall be the primary responsibility of sprinkler contractor to coordinate with other building trades to avoid architectural, structural, mechanical and electrical interference's. All necessary additional sprinklers, piping, and other equipment required to avoid such interferences shall be provided as part of the sprinkler contract without additional compensation after the bid is submitted. However, should a change be made in the work of other contractors or trades from that shown on the drawings which results in additional work for the sprinkler contractor, a reasonable and equitable adjustment in the contract sum may be made.

E. Sprinkler locations shown on drawings are recommendations only. Sprinkler design engineer shall verify and modify locations as necessary to provide a code-compliant, functional system. Sprinkler locations will be subject to review of the Owner and Architect/Engineer during the shop drawing review phase.

F. Wherever possible, install piping as high as possible so as not to interfere with the work of others. Wherever possible, place piping in concealed spaces above finished ceilings.

G. Group piping whenever practical at common elevations.

H. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Slope piping and arrange systems to drain at low points.

I. If it is discovered during installation that any component of the sprinkler system will be exposed to freezing conditions, the contractor shall notify the Architect/Engineer immediately.

J. Prepare all exposed pipe, fittings, supports, and accessories for finish painting. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding. Paint to match finish of adjacent walls surfaces.

K. Do not penetrate building structural members unless specifically indicated.

L. Provide sleeves when penetrating footings, fire rated floors and fire rated walls. Seal pipe and sleeve penetrations to achieve fire resistance equivalent to fire separation required.

M. Die cut screw joints with full cut standard taper pipe threads with red lead and linseed oil or other non-toxic joint compound applied to male threads only.

N. Install valves with stems upright or horizontal, not inverted.

O. Provide gate, ball or butterfly valves for shut-off or isolating service.

P. Provide drain valves at main shut-off valves, low points of piping and apparatus.

Q. Pipe main system drain valve and test connection to location outside building. See drawings.

R. Install equipment in accordance with manufacturer's instructions.

S. Install buried shut-off valves in valve box. Provide post indicator.

T. Provide backflow preventer as shown on drawings.

U. Locate fire department connection with sufficient clearance from walls, obstructions, or adjacent fire department connections to allow full swing of fire department wrench handle.

V. Install outside alarm gong on building wall in location coordinated with the Architect / Engineer.

W. All sprinklers installed in lay-in ceiling tiles shall be centered within the individual ceiling tile. Contractor shall provide all swing joints and/or offsets required to accomplish center locations. Ensure sprinklers are installed level with adjacent ceiling surface.

1. Do not install sprinklers that have been dropped, damaged, or show a visible loss of fluid. Never install sprinklers with cracked bulbs.

2. Sprinkler bulb protector shall be removed by hand after installation. Do not use tools or any other device(s) to remove the protector that could damage the bulb in any way.

X. Apply masking tape or paper cover to ensure concealed sprinkler head cover plates do not receive field paint finish.

Y. Flush entire piping system of foreign matter.

Z. Install pressure gauge on riser or feed main and at each sprinkler test connection.

AA. Install sprinkler storage cabinet in first floor mechanical room. Coordinate location with other trades.

BB. Install all valves, flow switches, and other accessories in accessible locations. Where these components are located in a concealed area, provide access panels.

CC. Sprinkler piping shall not be installed above any electrical panels, electrical transformers, fire alarm panels, or EMCS panels, regardless of distance above.

3.3 FIELD QUALITY CONTROL

A. Hydrostatically test entire system per NFPA 13. Test shall be witnessed by authority having jurisdiction.

B. Perform a system test with a fire department pumper truck to verify acceptable pressure (typically 100 psig). Connect pumper truck to fire department connection for test. Coordinate with authority having jurisdiction and local fire department.

C. Note each test in Pipe Pressure Test Log provided in section 21 05 00 of these specifications. Submit test log to Engineer for review before final project closeout. Furnish copy of test log with operation and maintenance data.

D. The contractor shall furnish and sign copy of Contractor's Material and Test Certificate as provided in NFPA, Section 8-1 (Figure 8-1). Submit certificate to Engineer for review before final project closeout. Furnish copy of certificate with operation and maintenance data.

END OF SECTION

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SECTION 22 05 00
BASIC PLUMBING REQUIREMENTS

1. GENERAL

1.1 SECTION INCLUDES

A. This section describes Basic Mechanical Requirements required to provide for a complete installation of all mechanical systems for this project. This section shall apply to all other Division 22 specification sections as well as all work shown on the drawings.

B. It is the intent of the Mechanical Division of the Specifications that all mechanical work specified herein be coordinated as required with the work of all other Divisions of the Specifications and Drawings so that all installations operate as designed.

C. All systems shall be completely assembled, tested, adjusted and demonstrated to be ready for operation to the satisfaction of the Owner's representative.

D. The Contractor shall note that, in some cases, piping as shown on the Drawings provide general location and routing information only. The Contractor shall be responsible for providing interference-free systems with proper clearance to facilities and equipment.

E. Where the word "provide" is used, it shall mean "furnish and install" unless otherwise noted or specified.

F. Note that the words "mechanical" and "plumbing" are used interchangeably throughout the Division 22 and 23 specification sections.

1.2 RELATED SECTIONS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this section and all other sections of Division 22.

1.3 DESCRIPTION OF WORK

A. The work included under this section consists of providing all labor, materials, supervision, and construction procedures necessary for the installation of the complete mechanical systems required by these specifications and/or shown on the drawings of the contract.

B. The Contract Drawings are shown in part diagrammatic intended to convey the scope of work, indicating the intended general arrangement of equipment, piping fixtures, etc. The Contractor shall follow the drawings in laying out work and verify clearances for the installation of the materials and equipment based on the dimensions of actual equipment furnished. Whenever a question exists as to the exact intended location of outlets or equipment, obtain instructions from the Architect/Engineer before proceeding with the work.

C. All plumbing work shall comply with International Plumbing Code.

1.4 QUESTIONS OF INTERPRETATION

A. If questions arise during the bidding process regarding the meaning of any portion of the contract documents, the prospective bidder shall submit the questions to the Architect/Engineer for clarification. Any definitive interpretation or clarification of the contract documents will be published by addenda, properly issued to each person holding documents, prior to the bid date. Verbal interpretation or explanation not issued in the form of an addendum shall not be considered part of the bidding documents. When submitting questions for clarification, adequate time for issuance and delivery of addenda must be allowed.

B. The Architect/Engineer shall be the sole judge regarding interpretations of conflicts within contract documents.

1.5 CONTRACT DOCUMENT DISCREPANCIES

A. If any ambiguities should appear in the contract documents, the Contractor shall request clarification from the Architect/Engineer before proceeding with the work. If the Contractor fails to make such request, no excuse will thereafter be entertained for failure to carry out the work in a manner satisfactory to the Architect/Engineer. Should a conflict occur within the contract documents, the Contractor is deemed to have estimated the more expensive way of doing the work unless a written clarification from the Architect/Engineer was requested and obtained before submission of bid.

B. The Contractor acknowledges and understands that the Contract Documents are a two-dimensional representation of three-dimensional objects. This representation may include imperfect data, interpreted codes, utility guidelines, three-dimensional conflicts, and required field coordination items. Such deficiencies should be 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.

C. The Contractor shall follow the drawings in laying out work and verify clearances for the installation of the materials and equipment based on the dimensions of actual equipment furnished. Whenever a question exists as to the exact intended location of materials or equipment, obtain instructions from the Architect/Engineer before proceeding with the work.

D. If there is a conflict between manufacturer's recommendations and the Contract Documents, the manufacturer's recommendations shall govern with no additional cost to the Owner.

1.6 PERMITS

A. All permits, fees, licenses, etc. required for this project shall be obtained by the Contractor.

1.7 QUALITY ASSURANCE

A. Installers shall have at least 2 years of successful installation experience on projects with mechanical installation work similar to that required by the project. All equipment and materials shall be installed in a neat and workmanlike manner and shall be aligned, leveled, and adjusted for satisfactory operation, unless noted otherwise in other mechanical sections.

B. Manufacturer of equipment and materials must be regularly engaged in the manufacture of the specified equipment and material with similar construction and capacities and whose products have been in satisfactory use in similar service for not less than five (5) years, unless noted otherwise in other Mechanical Sections.

C. Qualify welding processes and operators for structural steel according to AWS D1.1. "Structural Welding Code - Steel.

D. Quality welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."

E. Comply with provisions of ASME B31 Series "Code for Pressure Piping", including all addenda.

F. Contractor signed welder certificate(s) shall be submitted. Certify that each welder has passed AWS qualification tests for the welding processes involved and that certification is current. A record shall be maintained on the job site showing the date and results of qualification tests for each welder employed on the job. One certified copy of the qualification test for each welder so employed shall be furnished to the Owner's representative.

G. For all the refrigerant work/service required by this project, all refrigerant technicians shall be EPA/ASHRAE 34 certified for corresponding classification type I, II, III and/or IV.

1.8 REFERENCES

A. The design, manufacture, testing, and method of installation of all equipment and materials furnished under the requirements of this specification shall conform to the following as applicable:

1. Safety and Health Regulations for Construction.

2. Occupational Safety and Health Standards, National Consensus Standards and Established Federal Standards.
3. ABMA - American Boiler Manufacturers Association.
4. ACCA - Air Conditioning Contractors of America.
5. ACGIH - American Conference of Governmental Industrial Hygienists.
6. ADC - Air Diffusion Council.
7. AGA - American Gas Association.
8. AIHA - American Industrial Hygiene Association.
9. AMCA - Air Movement and Control Association.
10. ANSI - American National Standards Institute.
11. ARI - Air-Conditioning and Refrigeration Institute.
12. ASA - Acoustical Society of American.
13. ASHRAE - American Society of Heating, Refrigerating, and Air-Conditioning Engineers.
14. ASME - The American Society of Mechanical Engineers.
15. ASTM - American Society of Testing and Materials.
16. BOCA – Building Officials and Code Administrators International.
17. CABO – Council of American Building Officials.
18. CAGI - Compressed Air and Gas Institute.
19. CTI - Cooling Tower Institute.
20. EJMA - Expansion Joint Manufacturers Association.
21. ETL - Engineering Tests Laboratory.
22. HEI - Heat Exchange Institute.
23. HI - Hydraulic Institute.
24. HYD I - Hydronics Institute.
25. IAPMO – International Association of Plumbing and Mechanical Officials.
26. ICBO - International Conference of Building Officials.
27. ICC – International Code Council.
28. NEBB - National Environmental Balancing Bureau.
29. NEC - National Electrical Code.
30. NEMA - National Electrical Manufacturers Association.
31. NFPA - National Fire Protection Association.
32. NSF - National Sanitation Foundation.
33. SAE - Society of Automatic Engineers.
34. SMACNA - Sheet Metal and Air Conditioning Contractors' National Association.
35. TEMA - Tubular Exchanger Manufacturers Association.
36. UL - Underwriters Laboratories, Inc.
37. International Plumbing Code.
38. International Mechanical Code.
39. Other governing, state, and local codes that apply.

1.9 SUBMITTALS

A. General: Follow the procedures specified in Division 1 Sections "General Conditions" and “Special Conditions”.

B. Shop drawings shall include the minimum following information as applies. Additional specific information required is outlined in other Mechanical Sections.

1. Certified performance and data with system operating conditions indicated. All coil, fan, and pump performance data shall be computer generated.
2. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicating, weights (shipping, installed, and operating), furnished specialties and accessories; and installation and start-up instructions.
3. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loading, required clearances, and methods of assembly of components.
4. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to electrical equipment. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring required for final installation of electrical equipment and controls. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
5. Maintenance Data: Submit maintenance data and parts list for each mechanical equipment, control and accessory; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual; in accordance with requirements of Division 1.

C. Coordination drawings

1. Drawings:

a. Provide coordination in determining adequate clearance and space requirements for fire suppression equipment, mechanical equipment, electrical equipment, and other items/equipment in the project. The Architect/Engineer reserves the right to determine space priority of equipment in the event of interference between pieces of equipment, piping, conduit, ducts and equipment of the trades. The Architect/Engineer will only review conflicts and give an opinion but will not perform as a coordinator.

b. Provide coordination drawings indicating structural components, reflected ceiling layout, fire suppression items, mechanical items, electrical items, and other systems. Indicate on the coordination drawings where components will be installed and how the service access area to such items shall be maintained. Illustrate items requiring access for maintenance or adjustment.

c. The Contractor will not be allowed any time extensions for participation in the coordination drawing process. The Contractor will not be allowed any contract cost extra for any additional fittings, rerouting or changes of duct size to equivalent sizes to those shown on the drawings that may be determined necessary through the coordination drawing process.

d. Deviations from the contract documents that are necessary for overall system installation and coordination shall be brought to the attention of the Architect/Engineer. Such necessary changes in the contract scope discovered through the coordination drawing process will be covered by the requirements of the "change order" process.

e. Access panels shall occur only in gypsum wallboard or plaster ceilings where indicated on the drawings or as needed to provide access to equipment, dampers, or valves. Access to fire suppression and other items shall be through accessible acoustical ceiling areas. Additional access panels will not be allowed without written approval from the Architect/Engineer at the coordination drawing stage and only after alternatives are reviewed. Layout changes shall be made to avoid additional access panels. If additional access panels are required, they shall be provided at no additional cost to the Owner.

f. Soffit penetrations and light alcoves shall be fully coordinated with hanging devices, studs, fire/smoke ratings, and structural support requirements.

2. The Contractor and subcontractors responsible for items of work located in or above ceilings shall participate in the coordination drawing process. Participation is mandatory. If the Contractor or subcontractor fails to participate in the coordination drawing process, the Owner reserves the right to do the following:

a. Stop construction progress payments for work performed by the Contractor. Payments will be reinstated only after the Contractor or subcontractor resumes participation in the coordination drawing process.

b. Require the relocation and resizing of components as necessary to ensure components will be installed as intended. In the event the Contractor did not participate in the coordination process, the Contractor will not be entitled to contract cost increases or time extensions due to Owner-initiated changes in the work.

c. The Contractor shall be held responsible for unnecessary rework that is attributable to failure to participate in the coordination process.

3. Drawings shall be prepared at 1/4 inch = 1 foot, 0 inches (minimum).

a. Coordination participants shall provide equipment installation and clearance requirements. This information shall be indicated on the coordination drawings.

b. Coordination drawings shall indicate the following major system components (including insulation, hub or connection widths with verification of turning radius):

1) Roof drain leaders
2) Large waste piping
3) Sprinkler mains
4) Equipment located above the ceiling
5) Heating hot water piping
6) Chilled water piping
7) Conduit runs 2 inches and larger
8) Cable tray
9) Bus duct

10) **Recessed light fixtures**
11) **Building wiring or cable trays**
12) **Ceiling heights as shown in contract documents and thickness of system**
13) **Soffits (including framing of supports)**
14) **Access points and clearances required**
15) **Access panels**
16) **Valves**
17) **Dampers**
18) **Coils**
19) **Ductwork**
20) **Fire-rated wall, partition, and floor penetrations**
21) **Steam and condensate piping**
22) **Space allotted for future utilities**
23) **Equipment in mechanical and electrical spaces**

c. **Information shall be delineated to indicate distances from column centerlines, pipe/equipment size, and distance from finished floor to bottom of pipe/equipment and hangers.**

4. **The coordination drawings shall be submitted to the Architect/Engineer and Owner's representative for review. The submitted coordination drawings shall indicate which contractors participated in the process and where conflicts appear to occur even after the priority ranking of utility routing has been utilized. In the event that conflicts require input from the Architect/Engineer, recommended solutions will be provided with the coordination drawings for review by the Architect/Engineer. The Architect/Engineer will review and return an opinion to the contractors for implementation. All contractors shall agree to the final coordinated layout by signing off on the coordination drawings before any construction can begin.**
5. **Maintain an updated set of coordination drawings at the job site reflecting changes, modifications and adjustments. Changes shall be reflected and sets or new sheets reissued to the Architect/Engineer and the Owner for review on a monthly basis with changes "clouded" and brought to the attention of the Architect/Engineer and the Owner.**
6. **When a change order request is issued, the affected subcontractors shall review the coordination drawings and bring to the attention of the Contractor and the Architect/Engineer revisions necessary to the work of others not directly affected by the change order.**
7. **Contractors that fail to cooperate in the coordination drawing effort shall be responsible for all costs incurred for adjustments to the work made necessary to accommodate installations. Provide adequate clearance and access through accessible ceilings. Conflicts that result after the coordination drawings are signed off will be the responsibility of the Contractor or subcontractor who did not properly identify their work or installed the work improperly.**

1.10 SUBSTITUTES

A. All proposals shall be based on providing and installing the materials or items of equipment which are hereinafter specified.

B. Equipment Selection: Equipment of greater or larger power, dimensions, capacities, and ratings may be furnished provided such proposed equipment is approved in writing. Associated mechanical and electrical services, circuit breakers, conduit, motors, bases, and equipment spaces are to be increased accordingly, but all recommended manufacturer clearances, etc., are to be maintained within the allotted mechanical spaces. No additional costs will be approved for these increases, if larger equipment is approved. If minimum energy ratings or efficiencies of the equipment are specified, the equipment must meet the design requirements and commissioning requirements.

C. Where the terms "or equivalent" is used, the Contractor may substitute alternate equipment, materials, etc. subject to review by the Architect/Engineer and the Owner's representative during the submittal phase of the project.

D. Where the term "or approved equivalent" is used, the Contractor may not substitute alternate equipment, materials, etc. unless requesting approval at least ten (10) days before the bid date. Notifications of any such approvals by the Architect/Engineer shall only be made in writing by Addendum.

E. Where the term "no equivalent" is used, the Contractor must provide the specified or scheduled equipment, materials, etc.

F. Final determination regarding substitutions shall be by the Architect/Engineer.

1.11 WARRANTY

A. Refer to the General Conditions section of this Specification for general warranty requirements and information. Additional warranty requirements are specified in subsequent Mechanical Sections.

1.12 CLOSE OUT AND OPERATION INSTRUCTIONS

A. Operate each system and item of equipment in a test run of appropriate duration, but no less than 7 days, to demonstrate sustained, satisfactory performance. Adjust and correct operations as required for proper performance.

B. Any system placed in temporary operation for testing or for the convenience of the Contractor during construction shall be properly maintained and operated by the Contractor.

C. All systems shall be protected against freezing, flooding, corrosion or other forms of damage prior to acceptance by the Owner.

D. Material or equipment damaged, shown to be defective or not in accordance with the Specifications shall be repaired or replaced to the satisfaction of the Owner's representative.

E. All tests shall be made after notification to and in the presence of the Owner's representative.

F. Before starting up any system, each piece of equipment comprising any part of the system shall be checked for proper lubrication and any other condition which may cause damage to the equipment or endanger personnel.

G. After systems have been demonstrated to be satisfactory for 7 consecutive days and ready for permanent operation, all permanent pipe line strainers shall be cleaned, valve and packings properly adjusted, lubrication checked and replenished if required. Temporary piping, etc. shall be removed and openings restored in a permanent manner acceptable to the Owner's representative.

H. Conduct a walk-through instruction seminar for the Owner's personnel pertaining to the continued operation and maintenance of mechanical equipment and systems. Explain the identification system, maintenance requirements, operational diagrams, temperature control provisions, sequencing requirements, security, safety, efficiency and similar features of the systems. Walk through must be documented as to those attending and subjects covered. Walk through document(s) shall be signed and dated by the contractor's representative and the owner's representative.

1. Provide instruction seminar, minimum 4 hours each, for each of the following items: Water Purification System WPS-1, Domestic Water Heater DWH-1, and Laboratory Water Heater LWH-1.

I. At the time of substantial project completion, turn over the prime responsibility for operation of the plumbing equipment and systems to the Owner's operating personnel. Until the time of final acceptance, provide full time operating personnel, who are completely familiar with the work, to consult with and continue training the Owner's personnel.

1. If any systems are operated prior to substantial completion, the contractor shall perform all necessary preventative maintenance according to all manufacturer recommendations.

1.13 RECORD DOCUMENTS

A. Prepare as-built documents in accordance with the requirements in Division 1 Section "PROJECT CLOSEOUT." In addition to the requirements specified in above, indicate the following installed conditions:

1. The Plumbing Contractor shall provide the Owner with as-built drawings for ductwork mains and branches, size and location, for both exterior and interior; locations of dampers and other control devices; filters, boxes, and terminal units and indicate all devices requiring periodic maintenance or repair, such as control power transformers, LACS panels/routers, field controllers, duct static pressure sensors, piping pressure sensors, etc.
2. All plumbing systems as described in the Specifications and/or shown on the drawings.
3. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.). Valve location diagrams, complete with valve tag chart. Refer to Division 22 Section "Plumbing Identification." Indicate actual inverts and horizontal locations of underground piping.
4. Equipment/material locations (exposed and concealed), dimensioned from prominent building lines.
5. All items must be dimensioned in horizontal and vertical plans to allow Architect/Engineer to update Building Information Model (BIM) file for Owner.

1.14 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1 Section "PROJECT CLOSEOUT." In addition to the requirements specified in Division 1, include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. Servicing instructions and lubrication charts and schedules.

B. Provide electronic copies, preferably in Adobe Acrobat Portable Document Format (pdf), of all maintenance manuals to Temperature Control Contractor for use in EMCS front-end system. Provide data in file types compatible with EMCS.

2. PRODUCTS (NOT APPLICABLE).

3. EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

B. Store and handle material and equipment in compliance with manufacturers' recommendations to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

C. Use proper lifting equipment where size/weight requires handling by such means.

D. Comply with manufacturer's rigging and moving instructions for unloading material and equipment, and moving them to final location.

E. Equipment requiring disassembly for access purposes shall be disassembled and reassembled as required for movement into the final location following manufacturer's written instructions.

F. Deliver material and equipment as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

G. Plumbing Contractor shall schedule deliveries so as to minimize space and time requirements for storage of materials and equipment on site.

3.2 ROUGH-IN

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

B. Refer to equipment specifications in Divisions 2 through 26 for rough-in requirements.

3.3 COORDINATION

A. Sequence, coordinate, and integrate installations of plumbing materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.

B. Coordinate the plumbing work with work of the different trades so that:

1. Interferences between mechanical, electrical, architectural, and structural work, including existing services, will be avoided.
2. Within the limits indicated on the drawings, the maximum practicable space for operation, maintenance repair, removal and testing of mechanical and other equipment will be provided.
3. Pipes, ducts, and similar items, shall be kept as close as possible to ceiling, walls, and columns, to take up a minimum amount of space. Pipes, ducts, and similar items shall be located so that they will not interfere with the intended use of other equipment.

C. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components as they are constructed.

D. Furnish and install, without additional expense to the Owner, all offsets, fittings and similar items necessary in order to accomplish the requirements of coordination.

3.4 PLUMBING INSTALLATIONS

A. All dimensions and clearances affecting the installation of work shall be verified in the field in relation to established datum, to building openings and to the work of other trades.

B. The location of all equipment and systems shall be coordinated to preclude interferences with other construction.

C. Should interferences occur which will necessitate deviations from layout or dimensions shown on the Drawings, the Architect/Engineer and the Owner's representative shall be notified and any changes approved before proceeding with the work.

D. Arrange for chases, slots, and openings in other building components during progress of construction to allow for mechanical installations.

E. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum possible headroom.

F. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

G. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect/Engineer.

H. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

I. Install plumbing equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.

J. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

K. Welding, sweating, or brazing operations

1. All cutting, welding, brazing, or sweating operations carried on in the vicinity of, or accessible to, combustible material shall be adequately protected to make certain that a spark or hot slag does not reach the combustible material and start a fire.
2. When it is necessary to do cutting, welding, brazing, or sweating close to wood construction, in pipe shafts, or other locations where combustible materials can not be removed or adequately protected, employ fireproof blankets and proper fire extinguishers. Position another individual nearby to guard against sparks and fire.
3. Whenever combustible material has been exposed to molten metal or hot slag from welding or cutting operations, or spatter from electric arc operations, a guard shall be kept at the place of work for at least one hour after completion to verify that smoldering fires have not been started.
4. Whenever welding or cutting operations are carried on in a vertical shaft or where floor openings exist, a fire guard shall be employed to examine all floors below the point of the welding or cutting operation. The fire guard shall be kept on duty for at least one hour after completion to verify that smoldering fires have not been started.
5. Before any work involving cutting, welding, brazing, or sweating operations is started, consult with the Architect/Engineer as to particular safety precautions to be employed on the work.

3.5 ACCESSIBILITY

A. All work shall be installed so as to be accessible for operation, maintenance and repair with particular attention given to locating valves, controls and equipment requiring periodic lubrication, cleaning, adjusting or servicing of any kind.

3.6 LUBRICATION AND TOOLS

A. Provide a fresh charge of lubricant in accordance with manufacturer's recommendations to all equipment requiring lubrication prior to start-up and maintain lubrication as required until acceptance by Owner.

B. Provide for each piece of equipment any special tools and a list of such tools required for the operation or adjustment of the equipment and turn over to the Owner's representative prior to final acceptance of the equipment.

3.7 PIPING SYSTEMS PRESSURE TESTING

A. The following personnel in the order listed shall be considered acceptable witnesses of all piping pressure testing:

1. Local Authority Having Jurisdiction
2. Owner's Representative
3. Mechanical Engineer / Architect
4. General Contractor's Foreman

B. Removal of pressure charge and associated drain down shall also be witnessed.

C. Mechanical contractor shall provide a minimum of 24-hour notice to at least one of the above listed parties before commencing any piping systems pressure test.

D. Pressure gauge requirements: Provide recently calibrated gauge with 4" face and a range such that test pressure is between 50% and 100% of gauge range. For example, a gauge with a 15 psig range is acceptable for a 10 psig pressure test, whereas a gauge with a 30 psig range is unacceptable in this application. Gauge resolution shall be suitable for type of testing, system size and test media. Gauge shall have been recently calibrated.

E. All piping pressurizing equipment (i.e., air compressor) shall be disconnected before test is commenced and shall remain disconnected for the entire duration of the test.

F. Entire system shall be properly vented before test is commenced.

G. For specific piping pressure testing requirements and procedures, see applicable piping systems specification sections.

H. Submit completed "Pipe Pressure Test Log" provided at the end of this Section for each pressure test before final project closeout. Test log shall also be included in operation and maintenance manuals.

NOTE: USE MULTIPLE FORMS IF NECESSARY

3.8 GENERAL CONTRACTOR - MECHANICAL EXTENT OF WORK

A. Access Panels

1. Furnish and install panels for access to valves and dampers and similar items where no other means of access, such as readily removable, sectional ceiling is shown or specified.
2. The plans indicate the location of all anticipated access panels. The Division 22 Contractor shall make every effort to locate all material and equipment requiring service and maintenance above accessible ceilings or utilize the indicated access panels. Material and equipment requiring service and maintenance that is shown above inaccessible ceilings shall be relocated to accessible or exposed areas whenever possible. When these items are located in exposed areas, the Division 22 Contractor is to verify with the Architect/Engineer that the installation will not affect the aesthetics of the building. However, when it is not possible to locate these items in accessible or exposed areas due to the configuration of the actual installation of the mechanical and other trade systems or aesthetic reasons, additional access panels shall be provided. The contractor shall be equitably compensated for the additional access panels.

3. Refer to Section 08 31 13 – Access Doors and Panels for specific information on type and size of panels

B. Cutting and Patching

1. General: Perform cutting and patching in accordance with Division 1 Section "CUTTING AND PATCHING." In addition to the requirements specified in Division 1, the following requirements apply:
2. The Division 22 Contractor shall coordinate all cutting and patching of holes, in existing building and new construction which are required for the passage of mechanical work.
3. Division 22 Contractor is to notify the General Contractor prior to submitting his bid, the number, size and location of all cutting and patching requirements. The Division 22 Contractor shall be liable for all associated costs of cutting and patching for mechanical work upon failure to notify the General Contractor prior to bid submission.
4. Under no circumstances shall any structural members, load-bearing walls or footings be cut without first obtaining written permission from the Engineer.
5. Cut, channel, chase and core drill floors, walls, partitions, ceilings, and other surfaces necessary for mechanical installations. Perform cutting by skilled mechanics of the trades involved.
6. Patching of concrete openings shall be filled with grout and finished smooth with the adjacent surface.
7. All below-grade openings for pipe shall be sealed with interlocking synthetic rubber line assembly, Link-Seal by Thunderline Corporation or equal.
8. **All penetrations through the walls, floor, or structure of laboratory spaces, laboratory support spaces, lecture halls, classrooms, conference rooms, corridors or other areas in which relative pressurization relationships are important shall be sealed airtight. Refer to the drawings for additional information regarding rooms in which maintaining pressurization is important.**
9. Repair cut surfaces to match adjacent surfaces.
10. Perform cutting, fitting, and patching of mechanical equipment and materials required to:

    a. Uncover work to provide for installation of ill-timed work.
    b. Remove and replace defective work.
    c. Remove and replace work not conforming to requirements of the Contract Documents.
    d. Remove samples of installed Work as specified for testing.
    e. Install equipment and materials in existing structures.
    f. Upon written instructions from the Architect, uncover and restore Work to provide for Architect/Engineer observation of concealed Work.

C. Excavation and Backfilling

1. Division 22 Contractor shall perform all excavation and backfilling necessary to install the required mechanical work. Coordinate the work with other excavating and backfilling work in the same area.

2. Except as indicated otherwise, comply with the applicable sections in Division 2 of these specifications, excavation filling and backfilling (for structures) to 5' outside the building line, and exterior utilities sections for beyond 5' from the building line.
3. Trenching: Trench width shall be no more than required for shoring, bracing and performance of the work. All necessary shoring and bracing shall be installed to insure worker safety, proper installation of mechanical work, and protection of adjacent structures. Provide all dewatering as required. Depth shall not exceed that required to achieve the specified depth of cover and overdig will be permitted for bedding material only. All trenches shall be open cut from the surface.
4. Bedding: All work shall be properly bedded whether on virgin soil or on granular bedding as specified. All granular bedding shall be laid on undisturbed soil. PVC and copper piping shall have a 4" crushed stone bed conforming to specification for granular material in Division 2. If rock is encountered, excavate to a point 4" below installed bottom elevation of piping and provide bedding as called for above.
5. Haunching: Haunching shall be brought up on both sides of the pipe for a distance of 1/3 the pipe diameter and shall be of the same material used for bedding.
6. Backfill: Backfilling shall not begin until installation has been tested for leaks.
7. Final Backfill shall be as follows:

    a. Outside Building Under Paved Areas: Granular material specified in Division 2.
    b. Outside Building and Not Under Paved Areas: Clean soil free of vegetable matter and foreign material or crushed limestone. In planted areas backfill to a point 6" below finished grade. Owner will provide topsoil to finished grade.

8. Placement: Place all granular material in lifts of 12" maximum compacted to 100% of maximum dry density as determined as ASTM D698. Place soil in 6" lifts compacted to 95% of maximum density as determined by ASTM D698. Do not place any backfill until excavations have been cleaned of all water, debris and loose or soft soil.
9. Protection: At least 72 hours prior to excavating, for each phase, Contractor shall contact the Owner's Representative to arrange for utility locates in the construction area.
10. Contractor shall provide temporary supports for all underground utilities crossing an excavation.
11. Provide all required barricades, fencing, signs, lights, etc. as necessary for the protection of the workers and of the general public.
12. Excess Material: All excess earth and other material resulting from the excavation shall be removed from site daily by the Contractor.
13. Landscape work, pavement, flooring and similar exposed finish work that is disturbed or damaged by excavation shall be repaired and restored to their original condition by the Mechanical Contractor.

D. Concrete Bases

1. Minimum 4" high concrete housekeeping pads shall be provided under floor mounted mechanical equipment. Concrete inertia pads shall be provided for all base-mounted pumps and air compressors installed in the penthouse area.

2. Division 22 Contractor is to notify the General Contractor prior to submitting his bid, the number, size and location of all mechanical equipment bases. The Division 22 Contractor shall be liable for all associated costs to install the mechanical equipment bases upon failure to notify the General Contractor prior to bid submission.
3. Construct concrete equipment bases a minimum 4 inches larger in both directions than supported unit. Follow supported equipment manufacturer's setting templates for anchor bolt and tie locations. Use 3000 psi, 28-day compressive strength concrete, reinforcement and forms as specified in Division 3 Section "Cast-In-Place Concrete." Coordinate final equipment base size with General Contractor.

E. Roof curbs, roof support for mechanical equipment and roof penetrations.

1. Division 22 Contractor is to coordinate with the General Contractor all roof curb and roof supports supplied, number, size and location of all roof penetrations. All major roof penetrations are shown on the architectural roof plan. General Contractor shall be notified of all additional roof penetrations provided by the Division 22 Contractor not shown on this plan. The General Contractor shall provide all roof deck mounted equipment and pipe supports, pipe penetrations and cut roof deck for pipe and duct penetrations, unless noted otherwise. The Division 22 Contractor shall furnish all roof curbs and the General Contractor shall install, unless noted otherwise. The Division 22 Contractor shall provide all roof covering/membrane mounted equipment and pipe supports and roof drains, unless noted otherwise.
2. The Division 22 Contractor shall be liable for all associated costs to install the roof curbs, roof supports and roof penetrations not shown on the roof plan or added after the roof system has been installed. Coordinate with the General Contractor prior to construction the number size and location of all roof penetrations.
3. Division 22 Contractor is to coordinate with the General Contractor all roof curb and roof supports supplied, number, size and location of all roof penetrations. All major roof penetrations are shown on the architectural roof plan. General Contractor shall be notified of all additional roof penetrations provided by the Division 22 Contractor not shown on this plan.

F. Painting

1. The General Contractor is to field paint mechanical equipment and materials in specified areas as noted on the mechanical plans, mechanical schedules and in the specifications. Division 22 Contractor is to coordinate the painting of these items with the General Contractor. The Mechanical Contractor is to provide materials in these areas that are suitable for accepting paint. The clean and preparation of the materials to reach paint is the responsibility of the General Contractor unless noted specifically to be responsibility of the Division 22 Contractor.
2. In concealed locations, field-fabricated bare iron or steel items required for installation of work under this Division shall have rough or sharp edges removed and shall be painted with one coat of zinc rich paint.

3. In exposed locations, field-fabricated bare iron or steel items required for installation of work under this Division shall have rough or sharp edges removed and shall be painted in accordance with Section 09 91 00.

3.9 ELECTRICAL-PLUMBING EXTENT OF WORK

A. The responsibility of work specified under Division 22 and 26 is clarified under, Section 22 05 13, "Electrical Requirements for Plumbing Equipment. Division 22 Contractor is to coordinate all electrical requirements prior to ordering powered plumbing equipment.

END OF SECTION

PIPE PRESSURE TEST LOG

PROJECT:

BUILDING:

GENERAL CONTRACTOR:

CLARK ENERSEN PROJECT NUMBER:

MECHANICAL CONTRACTOR:

TEST INFORMATION						TEST PRESSURE					
TEST DATE	PIPING SYSTEM	AREA TESTED	TEST MEDIA (WATER OR AIR)	TEST DURATION (MINUTES)	PRESSURE GAGE NUMBER	INITIAL (PSIG)	FINAL (PSIG)	TESTED BY	WITNESSED BY	PASS / FAIL (P/F)	COMMENTS

ADDITIONAL COMMENTS:

PRESSURE GAGE INFORMATION

GAGE NUMBER	MANUFACTURER	PRESSURE RANGE	RESOLUTION	STYLE	DIAL SIZE	GAGE NUMBER	MANUFACTURER	PRESSURE RANGE	RESOLUTION	STYLE	DIAL SIZE

NOTE: USE MULTIPLE FORMS IF NECESSARY

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SECTION 22 05 13
ELECTRICAL REQUIREMENTS FOR PLUMBING EQUIPMENT

1. GENERAL

1.1 SECTION INCLUDES

A. Electrical Requirements for:

1. Motors
2. Starters, Electrical Devices, and Wiring
3. Manual Motor Starters
4. Motor Connections
5. Capacitors
6. Safety Switches

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

A. Quality assurance.

1. Electrical components and materials shall be UL labeled and listed.

B. References.

1. The design, manufacture, testing and method of installation of all equipment and materials furnished under the requirements of this specification section shall conform to the following:

a. AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings.
b. AFBMA 11 – Load Ratings and Fatigue Life for Roller Bearings.
c. ANSI/IEEE 112 – Test Procedure for Polyphase Induction Motors and Generators.
d. ANSI/NEMA Standard MG 1 – Motors and Generators.
e. ANSI/NFPA 70 - National Electrical Code.
f. NEMA Standard ICS 2 – Industrial Control Devices, Controllers, and Assemblies.
g. NEMA Standard 250 – Enclosures for Electrical Equipment.
h. NEMA Standard KS 1 – Enclosed Switches.

C. Submittals.

1. No separate submittal is required. Submit product data for motors, starters, and other electrical components with submittal data required for the equipment for which it serves, or as required by the individual equipment specification sections.

D. Operation and maintenance manuals.

E. Project record documents.

F. Delivery, storage, and holding

G. Related sections.

1. Separate electrical components and materials required for field installation and electrical connections are specified in Division 26.

1.3 SUMMARY

A. This section specifies the basic requirements for electrical components which are an integral part of packaged plumbing equipment. These components include, but are not limited to factory installed motors, starters, and disconnect switches furnished as an integral part of packaged plumbing equipment. In addition, this section covers necessary coordination issues between plumbing and electrical disciplines. All plumbing and electrical construction documents must be completely reviewed by the Plumbing and Electrical Contractors prior to the submission of bids. Any discrepancies in the documents should be brought to the Architect/Engineer's attention at that time. Failure to properly coordinate or review documents in advance of submission of bids will not be valid cause for changes to the overall Contract amount.

B. Specific electrical requirements (i.e. horsepower and electrical characteristics) for plumbing equipment are scheduled on the Drawings.

2. PRODUCTS

2.1 MOTORS

A. The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications.

1. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.
2. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range. Minimum service factors shall be as follows:

Motor Service Factor Schedule		
Horsepower:	**3600 RPM:**	**1800 RPM:**
1/6 – 1/3	1.35	1.35
1/2	1.25	1.25
3/4	1.25	1.25
1 – 1.25	1.25	1.15
1.5 - 150	1.15	1.15

3. Two-speed poly-phase motors shall have two separate windings served by a single point electrical connection to the two speed starter. Two speed starters shall be located at the motor location unless otherwise noted.
4. Temperature Rating: Rated for 40 deg. C environment with maximum 50 deg. C temperature rise for continuous duty at full load (Class A Insulation).
5. Starting capability: Frequency of starts as indicated by automatic control system, and not less than five (5) evenly timed starts per hour for manually controlled motors.
6. Motor construction: NEMA Standard MG 1, general purpose, continuous duty, Design "B", except "C" where required for high starting torque.

    a. Frames: NEMA Standard No. 48 or 54; use driven equipment manufacturer's standards to suit each specific application.
    b. Bearings: Ball or roller bearings with inner and outer shaft seals; re-greasable; designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor; for fractional horsepower, light duty motors, sleeve type bearings are permitted.
    c. Enclosure Type: Open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation; guarded drip-proof motors where exposed to contact by employees or building occupants; weather protected Type I for outdoor use, Type II where not housed.
    d. Overload protection: Built-in thermal overload protection (in accordance with NEC requirements) and, where indicated, an internal sensing device suitable for signaling and stopping the motor at the starter.

7. Noise rating: "Quiet"
8. Efficiency: **"Premium efficiency"** motors, as defined in NEMA MG 1, most recent edition.
9. Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.
10. All three-phase motors shall be inverter duty type.
11. Motors Used With Variable Frequency Drives: Ratings, characteristics, and features coordinated with and approved by drive manufacturer. Motor shall be designed and labeled for use with variable frequency drives. Motor shall be designed with critical

vibration frequencies outside the operating range of the drive output and shall be suitable for use throughout speed range without overheating.

a. Provide AEGIS SGR, or approved equivalent, shaft grounding ring/system to divert adverse shaft currents away from the motor bearings. Use AEGIS Colloidal Silver Shaft Coating (PN CS015), or approved equivalent, prior to ring installation. Install coating and ring per manufacturer recommendations.

12. Motors Used for Wet or Corrosive Duty: 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.

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

HP	RPM(Syn)	NEMA Frame	Minimum Percent Efficiency	Minimum Percent Power Factor
1	1800	143T	82	84
1.5	1800	145T	84	85
2	1800	145T	84	85
3	1800	182T	86	86
5	1800	184T	87	87
7.5	1800	213T	88	86
10	1800	215T	89	85
15	1800	256T	91	85
20	1800	256T	91	86
25	1800	284T	91	85
30	1800	286T	92	88
40	1800	324T	92	83
50	1800	326T	93	85
60	1800	364T	93	88
75	1800	365T	93	88
100	1800	404T	93	83
125	1800	405T	93	86
150	1800	444T	93	85
200	1800	445T	94	85
1.5	3600	143T	82	85
2	3600	145T	82	87
3	3600	145T	84	85
5	3600	182T	85	86
7.5	3600	184T	86	88

PERFORMANCE SCHEDULE: THREE PHASE-ENERGY EFFICIENT, TOTALLY ENCLOSED, FAN COOLED

HP	RPM(Syn)	NEMA Frame	Minimum Percent Efficiency	Minimum Percent Power Factor
1	1800	143T	82	84
1.5	1800	145T	84	85
2	1800	145T	8	85
3	1800	182T	87	83
5	1800	184T	88	83
7.5	1800	213T	89	85
10	1800	215T	90	84
15	1800	254T	91	86
20	1800	256T	91	85
25	1800	284T	92	84
30	1800	286T	93	86
40	1800	324T	93	83
50	1800	326T	93	85
60	1800	364T	93	87
75	1800	365T	93	87
100	1800	405T	94	86
125	1800	444T	94	87
150	1800	445T	94	88
200	1800	447T	95	87
1.5	3600	143T	82	85
2	3600	145T	82	87
3	3600	182T	82	87
5	3600	184T	85	88
7.5	3600	213T	86	86
10	3600	215T	86	86

2.2 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 shall be responsible for replacement sheaves required to achieve specified performance. Coordinate with testing and balancing of the equipment.

2.3 STARTERS, ELECTRICAL DEVICES, AND WIRING

A. Motor-Starter Characteristics: Motor starters shall be compatible with the equipment they serve. In general, motor starter characteristics shall meet the requirements of Division 26 specification sections and as outlined as follows:

B. Motor Connections

1. Provide connections to motors in accordance with the requirements listed in the electrical specifications.
2. See Division 26 for the use of lugs for motor connections.

C. Capacitors

1. Capacitor features shall include:

a. Individual unit cells.
b. All welded steel housing.
c. Each capacitor shall be internally fused.
d. Non-flammable synthetic liquid impregnate.
e. Craft tissue insulation.
f. Aluminum foil electrodes

2. KVAR size shall be determined by the Contractor/Supplier and shall correct motor power factor to 95 percent or better and shall be installed on all motors 10 horsepower and larger that have an uncorrected power factor of less than 85 percent at rated load. Power factor correction is not required for motors used in conjunction with variable frequency drives.

D. FULL VOLTAGE NON-REVERSING MAGNETIC STARTERS

1. See specification section 26 29 13 – Motor Controllers for requirements.

E. FULL VOLTAGE NON-REVERSING COMBINATION STARTERS

1. See specification section 26 29 13 – Motor Controllers for requirements.

F. MANUAL MOTOR STARTERS

G. See specification section 26 29 13 – Motor Controllers for requirements.

H. CAPACITORS

1. Capacitor features shall include:

a. Individual unit cells.
b. All welded steel housing.
c. Each capacitor shall be internally fused.
d. Non-flammable synthetic liquid impregnate.

e. Craft tissue insulation.
f. Aluminum foil electrodes

2. KVAR size shall be determined by the Contractor/Supplier and shall correct motor power factor to 95 percent or better and shall be installed on all motors 10 horsepower and larger that have an uncorrected power factor of less than 85 percent at rated load. Power factor correction is not required for motors used in conjunction with variable frequency drives.

2.4 SAFETY SWITCHES

A. See specification section 26 05 01 – Basic Electrical Materials and Methods.

3. EXECUTION

3.1

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.

3.2 CONTRACTOR COORDINATION

A. It is the responsibility of the Contractor and all Subcontractors to coordinate scope to ensure that all required electrical connections and control connections are provided in accordance with all specification sections. The Architect/Engineer is not responsible for determining which Contractor or Subcontractor will provide particular items.

END OF SECTION

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SECTION 22 05 19
PLUMBING METERS AND GAUGES

1. GENERAL

1.1 SECTION INCLUDES

A. Positive displacement meters.

B. Water meters.

C. Calibrated balance valves.

D. Pressure gages and pressure gage taps.

E. Thermometers and thermometer wells.

F. Piping pressure and temperature test plugs.

G. Sight flow indicators.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

B. References

C. Submittals

D. Operation and maintenance manuals.

E. Project record documents

1. Accurately record actual locations of instrumentation.

F. Delivery, storage, and handling

1.3 REGULATORY REQUIREMENTS

A. Perform Work in accordance with International Plumbing Code.

B. Provide lead-free materials (0.25% lead by weighted average) for applicable potable water meters, materials, piping, valves, fittings, backflow preventers, and other items in accordance with NSF/ANSI 61, including Appendix G.

C. Provide lead-free materials (0.25% lead by weighted average) for applicable potable water faucets, faucet connectors, hoses, supply stops, and other items in accordance with NSF/ANSI 61, including Appendix 9-G.

1.4 ENVIRONMENTAL REQUIREMENTS

A. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

2. PRODUCTS

2.1 DOMESTIC WATER METER AND IRRIGATION DEDUCT WATER METER

A. Materials

1. The University of Missouri has standardized on bronze disc, and electromagnetic utility meters as manufactured by BadgerMeter, Milwaukee, WI. Substitutes will not be accepted.
2. Nutating Disc Meter

    a. Construction shall comply with ANSI and AWWA C700 standards as required for domestic water metering applications.
    b. Meter housing and housing top plate shall be lead free cast bronze construction. The measuring chamber, disc, strainer, and generator housing shall be thermoplastic construction. Register lid and box shall be thermoplastic and bronze and trim shall be stainless steel or bronze.
    c. Register shall be a straight-reading odometer-type totalization display (gallons), 360 degree test circle with center sweep hand and flow finder to detect leaks. Register shall be installed using TORX tamper resistant seal screws. Meters shall be provided with an integral strainer. A tamper resistant calibration plug seal shall also be provided to protect from unauthorized personnel.
    d. Meters shall be Recordall disc models 35, 70, 120 and 170.

3. Electromagnetic Meter

    a. Electromagnetic meter tube shall be constructed 316 Stainless Steel.
    b. Metering tube end connections shall be carbon steel flanged, according to ANSI B16, Class 150.
    c. Insulating liner material shall have a NSF lining.

d. Metering tube shall include two self-cleaning measuring electrodes. The electrodes shall be Alloy C.
e. Metering tube shall include a third “empty pipe detection” electrode located in the upper portion of the inside diameter of the flow tube.
f. Meter shall include a fourth, grounding electrode at the 5 o’clock position.
g. Meter shall include mounted amplifier.
h. Water meter shall be specified as DC powered, 10-36VDC.
i. Meter shall be Badger M2000 Electromagnetic Flow Meter with daughterboard for MODBUS RS485 communication, installed.

4. Water Pressure Sensor

a. A water pressure sensor shall be installed and wired to the EM Process Control Panel.
b. Keller Preciseline High Accuracy Pressure Sensor or approved equal. Pressure range of 0-200 psig. 4-20 + RS485 output, ½” NPT conduit fitting connector. - Part number 0308.01102.051903.13.

B. See Plumbing Meters Schedules for specific performance requirements.

2.2 CALIBRATED BALANCE VALVES

A. Pre-Set Balance Feature. Valves to be designed to allow Installing Contractor to pre-set balance points for proportional system balance prior to system start-up in accordance with scheduled flow rates.

B. Valve Design and Construction. All valves 1/2" to 3" pipe size to be of bronze body/brass ball construction with glass and carbon filled TFE seat rings. Valves to have differential pressure read-out ports across valve seat area. Read-out ports to be fitted with internal EPT insert and check valve. Valve bodies to have 1/4" NPT tapped rain/purge port. Valves to have memory stop feature to allow valve to be closed for service and then reopened to set point without disturbing balance position. All valves to have calibrated name plate to assure specific valve settings. Valves to be leak-tight at full rated working pressure.

C. Valves 4" pipe size to be of cast iron body/brass vane construction with differential pressure read-out ports fitted with internal EPT insert and check valve.

D. Performed Insulation. All vales to be provided with molded insulation to permit access for balance and read-out.

E. Design Pressure/Temperature.

1. 1/2" - 3" NPT connections 300 psig to 250 deg. F.
2. 1/2" and 3/4" Sweat connections 200 psig at 250 deg. F.

3. 4" flanged connections 125 psig at 250 deg. F.

F. Calibrated balance valves to be ITT Bell and Gossett Model CB or equivalent.

2.3 PRESSURE GAUGES

A. Type: General use, ASME B40.1, Grade A, phosphor bronze bourdon-tube type, bottom connection, liquid-filled.

B. Case: Drawn steel or brass, glass lens, 4-1/2-inches diameter.

C. Connector: Brass, 1/4-inch NPS.

D. Scale: White coated aluminum, with permanently etched markings.

E. Accuracy: Plus or minus 1 percent of range span.

F. Range: Conform to the following:

1. Vacuum: 30 inches Hg to 15 psi.
2. All fluids: 2 times operating pressure.

2.4 PRESSURE GAUGE ACCESSORIES

A. Syphon: 1/4-inch NPS straight coil constructed of brass tubing with threads on each end.

B. Snubber: ASME B40.100, 1/4-inch NPS brass bushing with corrosion-resistant porous metal disc. Disc material shall be suitable for fluid served and rated pressure. Provide extension for use on insulated systems.

2.5 THERMOMETERS, GENERAL

A. Accuracy: Plus or minus 1 percent of range span or plus or minus one scale division to maximum of 1.5 percent of range span.

B. Scale range: Temperature ranges for services listed as follows:

1. Domestic Hot Water: 30 to 240 deg with 2-degree scale divisions (0 to 115 deg C with 1-degree scale divisions).
2. Domestic Cold Water: 0 to 100 deg F with 2-degree scale divisions (minus 18 to 38 deg C with 1-degree scale divisions).

2.6 LIQUID-IN-GLASS THERMOMETERS

A. Case: Die cast, aluminum finished, in baked epoxy enamel, glass front, spring secured, 9 inches long.

B. Adjustable Joint: Finished to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.

C. Tube: Red reading, mercury filled, magnifying lens.

D. Scale: Satin-faced, nonreflective aluminum, with permanently etched markings.

E. Stem: Copper-plated steel, aluminum or brass, for separable socket, length to suit installation.

F. ASME B40.200

2.7 GLASS THERMOMETERS

A. Standard: ASME B400.200.

B. Case: Die cast, aluminum finished, in baked epoxy enamel, glass front, spring secured, 9 inches long.

C. Adjustable Joint: Finished to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.

D. Tube: Red reading, magnifying lens, with non-mercury fluid.

E. Scale: Satin-faced, nonreflective aluminum, with permanently etched markings.

F. Stem: Copper-plated steel, aluminum or brass, for separable socket, length to suit installation.

2.8 THERMOMETER WELLS

A. Thermometer Wells: ASME B40.200, Brass or 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.

2.9 PIPING PRESSURE AND TEMPERATURE TEST PLUGS

A. Test Plugs shall be nickel-plated brass body, with 1/2-inch NPS fitting and 2 self-sealing valve-type core inserts, suitable for inserting a 1/8-inch O.D. probe assembly from a dial-type thermometer or pressure gage. Test plug shall have gasketed and threaded cap with retention chain and body of length to extend beyond insulation. Pressure rating shall be 500 psig.

B. Core Material: Conform to the following for fluid and temperature range:

1. Air, Water, Oil, and Gas, 20 to 200 deg F (minus 7 to 93 deg C): Neoprene.

2.10 SIGHT FLOW INDICATORS

A. Bronze or stainless-steel body, with sight glass and paddle wheel indicator, threaded or flanged ends.

B. Minimum pressure rating: 150 psig.

C. Minimum temperature rating: 200 deg F.

D. End connections for NPS 2 inch and smaller: Threaded.

E. End Connections for NPS 2-1/2 inch and larger: Flanged.

3. EXECUTION

3.1 GENERAL

A. Install in accordance with manufacturer's instructions.

3.2 THERMOMETERS

A. Install thermometers in vertical and tilted positions to allow reading by observer standing on floor.

B. Install as shown on drawings.

C. Thermometer Wells: Install in piping tee where thermometers are indicated, in vertical position. Fill well with oil or graphite and secure cap. Provide extension on insulated systems. Install in socket extending to center of pipe.

D. Connect water meters to EMCS for remote reading capability.

3.3 PRESSURE GAUGES

A. Install pressure gauges in piping tee with pressure gauge valve, located on pipe at most readable position.

B. Install as shown on plans, and elsewhere as indicated.

C. Pressure Gauge Ball Valves: Install in piping tee with snubber. Install syphon in lieu of snubber for steam pressure gages.

D. Pressure Gauge Accessories:

1. Install ball valve between system and pressure gauge.
2. Install in piping tee with snubber.

E. If applicable, cut rubber nipple on top of pressure gauge per manufacturer recommendations.

3.4 TEST PLUGS

A. Test Plugs: Install where indicated, located on pipe at most readable position. Secure cap.

3.5 FLOW MEASURING METERS

A. Installation:

1. Installation of water meter, valving, bypass loop and water sampler/test outlet shall be in strict accordance with manufacturer's printed instructions and recommendations, applicable ANSI and AWWA requirements, and as detailed on "Water_Meter Detail."
2. The preferred location for water revenue meter installation is within a building mechanical room. In some cases, water meter may need to be installed in an exterior below-grade meter pit. These pit installations shall be installed in strict accordance with manufacturer's printed instructions and University of Missouri "Meter Box Pit Detail" drawing.
3. Water meters shall be installed with a three-valve bypass design using ball valves (2" or less) or OS&Y rising stem gate valves (larger than 2"). The bypass valve shall be full-flow and capable of being locked. All other valves associated with the meter installation shall be ball valves. Electromagnetic water meters shall be installed in a straight run with no obstructions a minimum of ten diameters upstream and five diameters downstream. 2.4.
4. Water meter shall be installed after the backflow prevention device but prior to any booster pumps or pressure reducing valves.
5. Water meter shall be installed no greater than 4' from the floor in an accessible location. Variations from this requirement need prior approval from system owner.

B. Commissioning

1. Water service will not be turned on until the water meter is fully installed, powered and operating satisfactorily, the downstream water piping is successfully leak tested and secure (including freeze protection), and the necessary backflow preventer device is installed and successfully tested with the delivery of the test report to the Owner's Representative.
2. MU Only: Only Energy Management Steam and Water Distribution personnel will be authorized to turn water service on or off. Connect meter to EMCS. Coordinate with controls contractor and provide all necessary interconnections for accurate transmission of data.

3.6 ADJUSTING AND CLEANING

A. Adjusting: Adjust faces of meters and gauges to proper angle for best visibility.

B. Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touch-up paint.

END OF SECTION

SECTION 22 05 29
PLUMBING HANGERS AND SUPPORTS

1. GENERAL

1.1 SECTION INCLUDES

A. Pipe and equipment hangers, supports, stands, anchors, saddles and shields.

B. Sleeves and seals.

C. Mechanical sleeve seals.

D. Flashing and sealing equipment and pipe stacks.

E. Sealants, firestop insulation, putty and compounds.

F. Mechanical seals.

1.2 REFERENCES

A. ANSI/ASME B31.1 – Power Piping.

B. ANSI/AMSE B31.9 – Building Services Piping.

C. MSS SP-58 – Pipe Hangers and Supports – Materials, Design, and Manufacture.

D. MSS SP-69 – Pipe Hangers and Supports – Selection and Application.

E. MSS SP-89 – Pipe Hangers and Supports – Fabrication and Installation Practices.

1.3 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING GUIDELINES

A. References

B. Submittals

C. Delivery, storage and handling

D. Quality Assurance

2. PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

A. Plumbing Piping:

1. Conform to International Plumbing Code, International Fuel Gas Code, ASME B31.9, ASTM F708, MSS SP58, MSS SP69 and MSS SP89 as applicable.

B. Deionized Water Piping and Laboratory Waste and Vent Piping:

1. Conform to manufacturer's recommendations, MSS SP58, MSS SP69, MSS SP89, as applicable. Refer to 22 67 00 and 22 10 00 for additional information.

C. Natural Gas Piping:

1. Conform to International Fuel Gas Code, MSS SP58, MSS SP69, MSS SP89, as applicable.

D. Compressed Air, Vacuum, and Laboratory Gas (Nitrogen, Argon, Helium, etc.) Piping:

1. Conform to ASME B31.9, MSS SP58, MSS SP69, MSS SP89, as applicable.

E. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

F. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

G. Hangers and Supports:

1. Hangers for Hot and Cold Pipe Sizes 1/2 to 1-1/2 Inch, Carbon steel, adjustable swivel, band type.
2. Hangers for Cold Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.

3. Hangers for Hot Pipe Sizes 2 to 4 Inches; Carbon steel, adjustable, clevis.
4. , cast iron roll, double hanger.
5. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
6. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 Inches and Over: Steel channels with welded spacers and hanger rods, cast iron roll.
7. Wall Support for Hot Pipe Sizes 6 Inches (150 mm) and Over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.
8. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
9. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp.
10. Vertical Support: Steel riser clamp.
11. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
12. Floor Support for Hot Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
13. Floor Support for Hot Pipe Sizes 6 Inches and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
14. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
15. Hangers for insulated pipe shall be enlarged to compensate for insulation thickness so that hangers support insulation. See Section 22 07 19.
16. Roof Support for Hot and Cold Pipe: See PIPE STANDS section below.
17. **Hangers for insulated pipe shall be enlarged to compensate for insulation thickness so that hangers support insulation. See Section 22 07 19.**
18. See Section 22 05 48 for vibration isolation hangers and supports.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
2. Standard: MFMA-4.
3. Channels: Continuous slotted steel channel with inturned lips.
4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.4 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Internally Threaded Screw Anchors: Internally threaded, self tapping screw anchors, Power Fasteners Snake or approved equivalent.

1. Tested in accordance with ACI 355.2 and ICC-ES AC193 for use in structural concrete under the design provisions of ACI318 (Strength Design method using Appendix D)

2.5 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:

1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: Plastic.
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One or more; plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.6 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.7 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength

2.8 ACCESSORIES

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

2.9 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.

B. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.10 FLASHING

A. Metal Flashing: 26 gage galvanized steel.

B. Metal Counterflashing: 22 gage galvanized steel.

C. Lead Flashing:

1. Waterproofing: 5 lb/sq ft sheet lead
2. Soundproofing: 1 lb/sq ft sheet lead.

D. Flexible Flashing: 47 mil thick sheet buty; compatible with roofing.

E. Floor Drain and Floor Sink Flashing: 40 mil thick chlorinated polyethylene (CPE), equivalent to Chloraloy.

F. Caps: Steel, 22 gage minimum; 16 gage at fire resistant elements.

2.11 SLEEVES

A. Sleeves for Pipes Through Non-fire Rated Floors: 18 gage galvanized steel.

B. Sleeves for Pipes Through Non-fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Steel pipe or 18 gage galvanized steel.

C. Sleeves for Pipes Through Fire Rated and Fire Resistive Floors and Walls, and Fire Proofing: Prefabricated fire rated sleeves including seals, UL listed.

D. Sleeves for Pipes Through Rated Floors and Walls: Schedule 40 steel pipe.

2.12 SEALANTS, FIRESTOP INSULATION, PUTTY, AND COMPOUNDS

A. Firestopping Insulation: Glass fiber type, non-combustible, UL listed.

B. Firestop Putty: Non-harding, non shrinking, UL listed.

C. Firestop Compounds: Cementitous material, non-shrinking, UL listed.

D. Sealants:

1. Non fire/smoke rated partitions: Acrylic or silicone based caulking.
2. Fire/smoke rated partitions: Silicone based caulking, UL listed.

2.13 MECHANICAL SEALS

A. Mechanical Seals: Modular mechanical type, consisting of interlocking EPDM synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with type 316 stainless steel bolts and reinforced plastic polymer pressure plates which cause rubber sealing elements to expand when tightened, providing a watertight and gas-tight seal and electrical insulation. Provide Advance Products & Systems Model Innerlynx or equivalent.+

1. A sleeve shall be provided for each mechanical seal.

a. Thermoplastic sleeves: Sleeve shall have smooth walls and shall be made of molded non-metallic high density polyethylene (HDPE) with an integral solid water stop, Advance Products & Systems Model PWS or equivalent.
b. Steel sleeves: Sleeve shall have smooth walls, shall be made of Schedule 40 steel with an integral welded solid water stop, and shall have corrosion-resistant coating, Advance Products & Systems Model GWS or equivalent.

3. EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.2 INSERTS

A. Provide inserts for placement in concrete formwork.

B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.

D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

E. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.3 PIPE HANGERS AND SUPPORTS

A. Reference applicable codes for maximum support spacing; see Section 22 05 00. Additional supports shall be provided at other locations as specified in this Section.

B. Support piping adjacent to large pipe accessories such as valves, air separators, traps, etc. Provide additional supports as recommended by accessory manufacturer.

C. Independently support valves 16" and larger.

D. Install all hangers, supports, and accessories that shall be attached to structural steel prior to the application of structural steel fireproofing. Repair fireproofing if damaged during remainder of project.

E. Support horizontal piping as scheduled.

F. Support fire protection systems piping independently from other piping systems. Fire main piping may be trapezed with other piping systems. Coordinate trapeze hangers with the Sprinkler Contractor.

G. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.

H. Place hangers within 12 inches of each horizontal elbow.

I. Use hangers with 1-1/2 inch minimum vertical adjustment.

J. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.

K. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.

L. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

M. Support riser piping independently of connected horizontal piping.

N. Provide copper plated hangers and supports for non-insulated copper pipe.

O. Design hangers for pipe movement without disengagement of supported pipe.

P. Prime coat steel hangers and supports in the mechanical room and other exposed areas. Refer to the Architectural reflected ceiling plans for location of exposed ceilings. Hangers and supports located in attic space, crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

Q. Adjust hangers to distribute loads equally on attachments and to achieve specified pipe slopes.

R. Space hangers for pure water and laboratory waste and vent systems to avoid pipe sags. Use manufacturer-recommended V-groove channel if necessary to maintain sag-free installation.

S. Saddles, Shields and Inserts

1. Install protection saddles MSS Type 39 where insulation without vapor barrier is indicated. Fill interior voids with segments of insulation that match adjoining pipe insulation.
2. Install protective shields MSS Type 40 on cold piping that has vapor barrier. Shields shall span an arc of 180 degrees (360 degrees on trapeze hangers with U-bolt clamps) and shall have dimensions in inches not less than the following:

NPS	LENGTH	THICKNESS
1 through 3-1/2	12	0.048
4	12	0.060
5 & 6	18	0.060
8 through 14	24	0.075
16 through 24	24	0.105

3. Pipes 8 inches and larger shall have wood inserts.
4. Insert materials shall be at least as long as the protective shield.
5. Provide manufacturer-recommended saddles, inserts, and/or shields where cellular foam insulation is used. The removal of sections of cellular foam insulation for the purpose of pipe support is not acceptable.

T. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

U. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

V. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

W. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

X. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

Y. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

Z. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

AA. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

BB. Install lateral bracing with pipe hangers and supports to prevent swaying.

CC. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

DD. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

EE. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

FF. Insulated Piping:

1. Attach clamps and spacers to piping.
    a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

4. Shield Dimensions for Pipe: Not less than the following:

   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
   f. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
   g. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.4 INSTALLATION OF ANCHORS

A. Install anchors at proper locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and with AWS Standards D1.1.

C. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions to control movement to compensators.

D. Anchor Spacings: Where not otherwise indicated, install anchors at ends of principal pipe runs, at intermediate points in pipe runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.

3.5 FLASHING

A. Provide flexible flashing and metal counterflashing where piping and ductwork penetrate weather or waterproofed walls and floors.

B. Flash floor drains in floors with topping over finished areas with CPE membrane, a minimum of 12 inches clear on sides with minimum 36 x 36 inch sheet size. Fasten flashing to drain clamp device.

C. Seal floor, shower, mop sink, etc. drains watertight to adjacent materials.

D. Provide acoustical lead flashing around ducts and pipes penetrating equipment rooms, installed in accordance with manufacturer's instructions for sound control.

E. Adjust storm collars tight to pipe with bolts; caulk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.

3.6 SLEEVES

A. Provide pipe and duct sleeves at all fire/smoke rated partitions, exterior wall penetrations and wall penetrations into exposed areas. Pipe and duct sleeves are not required for penetrations through non-rated concealed partitions.

B. At the Contractor's option, pipe sleeves may be omitted if the wall or floor is core drilled, except in areas potentially exposed to wet conditions (such as mechanical rooms, loading dock, generator room, penthouse, kitchen, etc.).

C. Set sleeves in position in formwork. Provide reinforcing around sleeves.

D. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.

E. Sleeves through floors shall be grinded flush with finish floor level. In areas potentially exposed to wet conditions (such as mechanical rooms, loading dock, generator room, penthouse, kitchen, etc.), sleeve shall extend a minimum of 2" above finish floor.

F. Where piping penetrates non-rated ceilings or walls, close off space between pipe or duct and adjacent work with urethane rod stock and caulk air tight.

G. Seal pipe penetrations through non-rated floors.

1. Where piping is not located in a rated shaft and it penetrates a single non-rated floor, close off space between pipe and adjacent work with urethane rod stock and caulk air tight.
2. Where piping is not located in a rated shaft and it penetrates multiple non-rated floors, close off space between pipe and adjacent work with appropriate fire-rated sealant, insulation, putty, or compound.

H. Where piping penetrates rated floor, ceiling, or wall, close off space between pipe or duct with appropriate fire rated sealant, insulation, putty or compound. Refer to the Drawings for fire/smoke rated wall locations and the appropriate ratings.

I. Install chrome plated steel escutcheons on piping at finished surfaces.

J. Waste, vent and storm pipe penetrations through the concrete floor slab shall be encased in the poured concrete slab.

K. PVC pipe casing around the cold and hot water and gas piping shall be encased in poured concrete when penetrating the floor slab. Seal the opening between the piping and PVC casing with putty or rigid polyisocyanurate insulation plug and seal with caulking.

L. Provide mechanical seals and sleeves through exterior wall and floor penetrations and 3 hour or higher fire rated partitions.

3.7 HANGER SCHEDULES

MAXIMUM PIPE SIZE Inches	**HANGER ROD HANGER SPACING** Feet	**DIAMETER** Inches
1/2 to 1-1/4	6.5	3/8
1-1/2 to 2	10	3/8
2-1/2 to 3	10	1/2
4 to 6	10	5/8
8 to 12	14	7/8
14 and Over	20	1
PVC (All Sizes)	6	3/8

A. Reference International Plumbing Code and International Fuel Gas Code where applicable.

B. Reference manufacturer's recommendations for pure water piping and laboratory waste and vent piping.

C. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

D. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

E. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

F. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers, and metal framing systems and attachments for general service applications.

1. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

G. Use padded hangers for piping that is subject to scratching.

H. Use thermal-hanger shield inserts for insulated piping and tubing.

I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Pipe Hangers

a. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
b. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
c. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
d. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
e. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
f. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
g. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
h. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
i. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
j. Vee Bottom Clevis Hanger: For suspension of flexible plastic piping, Cooper B-Line B3106 or equivalent. Include plastic pipe support channel, Cooper B-Line B3106V.

2. Pipe Clamps

a. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
b. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
c. Wall or Ceiling Mounted Pipe Strap/Clamp (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.

3. Pipe Supports

a. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
b. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.

c. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
d. Pipe Rollers (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
e. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
f. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
4. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
5. C-Clamps (MSS Type 23): For structural shapes. Shall only be connected to bottom joist chord if weight is 200 lbs or less.
6. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads. Shall only be connected to bottom joist chord if weight is 200 lbs or less.

7. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions. Shall only be connected to bottom joist chord if weight is 200 lbs or less.
8. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel. Shall only be connected to bottom joist chord if weight is 200 lbs or less.
9. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

10. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): For protection of pipe insulation; depth of saddle to be larger than insulation thickness. Fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

a. Horizontal (MSS Type 54): Mounted horizontally.
b. Vertical (MSS Type 55): Mounted vertically.
c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

O. Comply with MSS SP-69 for trapeze pipe-hanger selections.

P. Comply with MFMA-103 for metal framing system selections.

Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.8 MECHANICAL SEALS

A. Provide mechanical seals and sleeves through exterior wall and floor penetrations, and in 3-hour or higher fire rated partitions.

3.9 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.10 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.11 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

END OF SECTION

SECTION 22 05 33 - HEAT TRACE FOR PLUMBING PIPING

1. GENERAL

1.1 SECTION INCLUDES

A. Heat tracing for HVAC piping with the following electric heating cables:

1. Self-regulating, parallel resistance.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

A. Quality assurance.

1. Manufacturer Qualifications:

a. ISO-09001 registered.
b. Provide products consistent with UL 515, CSA 22.2 No 130.16, and IEEE 515.1 requirements.

2. Installer Qualifications:

a. System Installer to have complete understanding of product and product literature from manufacturer or authorized representative prior to installation.
b. Electrical connections to be performed by licensed electrician.

3. Certification System (Heating Cable and Connection Kits): c-UL-us Listed for freeze protection of metallic and non-metallic piping associated with HVAC and Plumbing systems.
4. Testing: Self-regulating heating cable to be qualified and tested to demonstrate a useful lifetime in excess of 20 years.

B. References.

1. The design, manufacture, testing and method of installation of all equipment and materials furnished under the requirements of this specification section shall conform to the following:

a. AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings.
b. AFBMA 11 – Load Ratings and Fatigue Life for Roller Bearings.
c. ANSI/IEEE 112 – Test Procedure for Polyphase Induction Motors and Generators.
d. ANSI/NEMA Standard MG 1 – Motors and Generators.

e. ANSI/NFPA 70 - National Electrical Code.
f. NEMA Standard ICS 2 – Industrial Control Devices, Controllers, and Assemblies.
g. NEMA Standard 250 – Enclosures for Electrical Equipment.
h. NEMA Standard KS 1 – Enclosed Switches.

C. Submittals.

1. Product Data: For each type of product.

a. Include:

1) Heating cable data sheet.
2) HVAC piping freeze protection design guide.
3) System installation and operation manual.
4) System installation details.
5) Connection kits and accessories data sheet.
6) Controller data sheet.
7) Controller wiring diagram.

b. Include rated capacities, operating characteristics, and furnished specialties and accessories.
c. Schedule heating capacity, length of cable, and electrical power requirement for each electric heating cable required.
d. Include heat loss calculations for each pipe including pipe and insulation characteristics, heat loss, and watts per foot supplied by the heating cable.

2. Shop Drawings: For electric heating cable.

a. Include plans, elevations, sections, and attachment details.
b. Include diagrams for power, signal, and control wiring.
c. Manufacturer to produce detailed design as described below.

3. Delegated-Design Submittal: For installed products indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation. Delegated design submittals include:

a. Heat Trace Circuit Layout Drawings, including:

1) Location/Identification of area to be traced.
2) Heater circuit number.
3) Electrical load.
4) Heater catalog numbers.

5) Heater termination points.
6) Start-up temperature.
7) Location of all components.
8) Material list and quantities of all components.
9) Heating cable layout.

b. Heat Trace Isometric, including:

1) Location of line.
2) Piping line numbers.
3) Valves, pumps, flanges, fittings, instruments.
4) Heat loss and heater output.
5) Electrical load.
6) Heater catalog number.
7) Heater termination points.
8) Design parameters.
9) Insulation type and thickness.
10) Position of all components.
11) Material schedule listing all components and quantities used.
12) Panel ID number.

c. Pipe Freeze Protection Detail Drawings: Project-specific Detail Drawings, including details showing:

1) Installation and positioning of all components.
2) Proper amounts of tracing for valves, pumps, flanges, fittings, instruments, etc.
3) Junction box layouts.

d. Control Panel Drawings: Drawings for each control panel shall include the following:

1) Physical arrangement and structural detail drawings.
2) Complete power and control wiring diagrams showing all internal wiring connections for electrical and instrument components in each control panel. All wires, terminals, and devices shall be numbered and tagged in accordance with system elementary diagrams.

e. System Wiring Diagram: Project-specific drawings (if applicable) including:

1) Interconnect of all major components.
2) Assignment of circuiting.
3) Connection of circuit wiring in terminal blocks.
4) Connection of sensor wiring.

5) Connection of external alarm wiring.

f. Controller Setpoint Schedule (if applicable) showing the following:

1) Circuit addresses.
2) Circuit set points,
3) Circuit alarms and settings.

4. Testing Instructions and Reporting Form: Provide documentation for use in preinstallation testing of heat-tracing system.

D. Operation and maintenance manuals.

1. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.
2. Testing: Completed system test report.

E. Project record documents.

F. Delivery, storage, and holding

1. Deliver products to site in original, unopened containers or packages with intact and legible manufacturers' labels identifying the following:

a. Product and Manufacturer.
b. Length/Quantity.
c. Lot Number.
d. Installation and Operation Manual.
e. Material Safety Data Sheet (MSDS).

2. Store heating cable in clean, dry location with a temperature range of 0 to 140 deg F.
3. Protect heating cable ends from moisture ingress until final termination of the heating cable is complete.

G. Related sections.

1. Section 230719 - HVAC Piping Insulation
2. Division 26 specification sections.

H. Warranty

1. Manufacturer Limited Warranty: Manufacturer agrees to repair or replace heat tracing products listed below that fail in materials or workmanship within specified warranty period, when such goods are properly installed, operated, and maintained in accordance with product documentation.

   a. Covered Products Include:

      1) Heating cables, connection kits, and accessories.
      2) Thermostats, controllers, panels, contactors, sensors, and accessories.

   b. Warranty Period: Two years from date of Substantial Completion.

2. PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Complete pipe freeze protection system for insulated pipes exposed to the risk of freezing. System consists of a self-regulating heating cable, connection kits, accessories, and energy-efficient control and monitoring controller. The heating cable shall have a polyolefin jacket for aboveground water piping or a fluoropolymer jacket for below-grade piping.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage manufacturer to design complete and functional heat-tracing system as required by Project documents.

2.3 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Basis-of-Design Product: Subject to compliance with requirements, provide RAYCHEM, a brand of nVent; XL-Trace Edge Pipe Freeze/Flow Maintenance or equal.

B. Source Limitations: Obtain heat-tracing components and controllers from single manufacturer. To ensure system integrity and meet warranty requirements, only components and controllers supplied by cable manufacturer are to be used.

C. The heating cable and connection kit shall be included in a c-UL-us Listed system.

D. Heating Element: Pair of parallel No. 16 AWG, nickel-coated, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled, nonheating leads with connectors at one end, and seal the opposite end with a watertight end seal. Cable shall be capable of crossing over itself without overheating.

E. Electrical Insulating Jacket: Flame-retardant modified polyolefin.

F. Ground Braid: Tinned-copper braid. Minimum 70 percent for ground path and mechanical ruggedness.

G. Outer Jacket: Required for all applications.

1. For above ground freeze protection of water lines where fuel oil or aqueous chemicals are not present, use a modified polyolefin with ultraviolet inhibitor**.**
2. For below-grade applications, grease waste, or where fuel oil or aqueous chemicals are present, use a fluoropolymer with ultraviolet inhibitor**.**
3. Outer jacket to be printed with cable model number, agency listings, batch number, and meter marks (for ease of installation within maximum circuit length).

H. Maximum Operating Temperature (Power On): 154 deg F for 3 W/ft., 5 W/ft. , and 8 W/ft.

I. Maximum Exposure Temperature (Power Off): 185 deg F.

J. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

K. Capacities and Characteristics:

1. Nominal Heat Output at 50 deg F : See details on plans.
2. Piping Diameter: See details on plans.
3. Electrical Characteristics for Single-Circuit Connection:

2.4 CONTROLS

A. Single Circuit Local Digital Controller.

1. Basis-of Design Product: RAYCHEM; C910-485.
2. Control self-regulating heating cable via an energy saving, programmable single-circuit controller to provide adjustable maintained temperatures in the range of -40 to 140 deg F (-40 to 60 deg C).
3. Provide one controller for each heat-tracing circuit

4. Controller to include self-test function to verify heat-tracing integrity at least once every 24 hours.
5. Controller Capabilities:

    a. Supply Voltage: 100 to 277 V ac.
    b. Enclosure: NEMA 4X FRP.
    c. Operating Temperature Range: -40 to 140 deg F
    d. Display: Six-character, alphanumeric LED.
    e. Control: DP mechanical relay type.
    f. Control Algorithms: On/Off. Proportional Ambient Sensing Control for energy savings.
    g. Monitoring:

        1) Temperature:

            a) Low Alarm: 0 to 180 deg F
            b) High Alarm: 0 to 200 deg F

        2) Ground Fault:

            a) Alarm Range: 20 to 100 mA.
            b) Trip Range: 20 to 100 mA

        3) Current:

            a) Low Alarm Range: 3. to 20 A, or off.

        4) Autocycle Test: Interval of 1 to 240 minutes or 1 to 240 hours.

    h. Temperature Sensor Inputs:

        1) Quantity: Two.
        2) Type: 100 ohm, platinum, 3-wire, shielded.

    i. Alarm Outputs:

        1) AC Relay: Isolated solid state triac, SPST, 0.75 A maximum, 100 to 277 VAC nominal.
        2) Dry Contact Relay: Pilot duty, 48 V ac/dc, 500mA maximum, 10 V maximum resistive switching
        3) Outputs: Normally Open or Normally Closed.

j. Stored Parameters:

1) Minimum temperature.
2) Maximum temperature.
3) Maximum ground fault current.
4) Maximum heater current.
5) Contactor cycle count.
6) Time in use.

k. Alarm Conditions:

1) Low and High temperature.
2) Low current.
3) Ground fault alarm and trip.
4) RTD failure.
5) Loss of programmed values.
6) EMR failure.

l. Communications:

1) Protocol: Modbus RTU.
2) Topology: Daisy Chain.
3) 26 AWG shielded twisted pair.

6. Temperature Sensors:

a. For each temperature sensing controller, provide at least one of the following:

1) One 100-ohm, platinum, 3-wire, shielded RTD for pipe temperature sensing.

a) Basis-of-Design Product: RAYCHEM; RTD-10CS.

2) One 100-ohm, platinum, 3-wire, shielded RTD for ambient temperature sensing.

a) Basis-of-Design Product: RAYCHEM; RTD-200.

7. Approval: Complete heat trace system (heating cable, connection kits, and controller) shall be listed by a Nationally Recognized Testing (NRTL) and marked for intended use of freeze protection of HVAC piping.

B. Multi-Circuit Distributed Digital Control System:

1. Control and monitor pipe freeze protection using a centralized control system with distributed power and control modules.

    a. Basis-of Design Product: RAYCHEM; ACS-30.

2. Multi-application: Distributed digital control system shall be pre-programmed with parameters to provide concurrent control for heating cables used for pipe freeze protection, flow maintenance, HVAC piping, hot water temperature maintenance, surface snow melting, roof and gutter de-icing, freezer frost heave prevention, and floor heating applications.
3. Central User Interface Terminal: For all programming.

    a. Basis-of Design Product: RAYCHEM; ACS-UIT3.
    b. Certification: c-CSA-us Certified.
    c. Terminal Display: Color LCD display with password protection to prevent unauthorized system access.
    d. Capable of communicating with up to 52 power control panels, where each panel can control up to five circuits and accept up to five temperature inputs.
    e. Digital control system shall be capable of assigning up to four temperature inputs per heat-tracing circuit.
    f. Capable of communicating with up to 16 remote monitoring modules, where each module can accept up to eight temperature inputs.
    g. USB port to allow for quick and easy software update.
    h. Programmable Alarm Contacts: Three, including an alarm light on enclosure cover.
    i. Provide separate offline software tool to allow users to preprogram digital control system and transfer program via USB drive or Ethernet.
    j. Enclosure: NEMA 4 for indoor or outdoor locations.

4. Power Control Panels:

    a. Basis-of-Design Products: RAYCHEM; ACS-PCM2-5.
    b. Certification: c-UL-us Listed.
    c. Enclosure: NEMA 4/12 enclosure approved for nonhazardous indoor and outdoor locations.
    d. Provide ground-fault and line current sensing alarming, switching and temperature inputs for five heat-tracing circuits.
    e. Contactors: Five 3-pole, 30A contactors, EMR type.
    f. Capable of operating at 120 to 277 V.
    g. Alarm contact, including alarm light on panel cover.

5. Digital Controller:

    a. Integrated adjustable GFPD (10 to 200 mA).

b. Capable of being configured for On/Off, ambient sensing, PASC and timed duty cycle control modes based on the application. PASC control proportionally energizes power to heating cable to minimize energy based on ambient sensed conditions.
c. Upon communication loss with user interface terminal, panels shall control with the last downloaded set point.
d. Include built-in self-test feature to verify proper functionality of heating cable system.
e. BMS Communication Protocol: BACnet or Metasys N2.
f. Variables monitored by digital controller and reported back to BMS include:

1) Temperature.
2) Ground-fault.
3) Current draw.
4) Power consumption.
5) Associated alarms.

6. Approval: Complete heat trace system (heating cable, connection kits, and controller) shall be listed by a Nationally Recognized Testing Laboratory (NRTL), and marked for intended freeze protection of metallic and non-metallic piping associated with HVAC, Plumbing, and Fire Suppression systems.

2.5 HEATING CABLE CONNECTION KITS

A. Basis-of-Design Product: RAYCHEM; RayClic.

B. Provide power connections, splices/tees, and end seal kits to properly connect and terminate heating cable circuit along specified length of piping.

C. Install splices, tees, and crosses underneath pipe insulation with service loops installed to allow for future service of piping.

D. Connection kits shall be rated NEMA 4X to prevent water ingress and corrosion. All components shall be UV stabilized and shall not require cutting into heating-cable core to expose bus wires.

E. Certification: c-UL-us Listed.

F. Locate connection kits above grade for buried applications.

2.6 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, cable ties, connection kits, and end seals all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Identification: Provide and install "Electric Heat Traced" labels on exterior of pipe insulation every 10 ft. (3 m) on opposite sides of pipe, and on all splices, tees, crosses, and power connections for entire length of heat traced piping.

C. Warning Labels: Refer to Section 230553 "Identification for HVAC Piping and Equipment."

D. Thermal Pipe Insulation:

1. Pipes to be thermally insulated in accordance with manufacturer's written requirements.
2. Thermal Insulation: Flame retardant, closed-cell with waterproof covering.

2.7 SYSTEM APPROVAL

A. Complete heat trace system (heating cable, connection kits, and controller) shall be listed by a Nationally Recognized Testing Laboratory (NRTL), and marked for intended freeze protection of metallic and non-metallic piping associated with HVAC, Plumbing, and Fire Suppression systems.

3. EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Prior to installation of heating cable system, verify that all piping that will be heat traced has passed all hydrostatic/pressure tests and is signed off by plumbing inspector.
2. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.

B. Preinstallation Testing:

1. Prior to installation of heating cable on piping, an insulation resistance test shall be performed by installing contractor to ensure integrity of heating cable as describe in the installation and maintenance manual.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protect all heating cable ends from moisture ingress until cable is terminated with end seals.

1. Basis-of-Design Product: RAYCHEM; RayClic-E end seals.

3.3 INSTALLATION

A. All heat-tracing components including power connections, splices, tees, and crosses or end seal, must be installed above grade and protected from abuse or damage. In accordance with NEC and CEC, electrical connections are not permitted to be installed below grade.

B. In the field, all heating cables shall be meggered with a minimum of 2,500 V dc for self-regulating cable. The following field megger readings shall be taken on each heating cable:

1. Heating cable shall be meggered when received at Project site before installation.
2. Heating cable shall be meggered after installation, but before insulation is installed.
3. Heating cable shall be meggered after insulation is installed.
4. Heating cable shall be meggered at final commissioning prior to being energized.
5. Insulation resistance must exceed 1.000 megohms at 2,500 V dc
6. All results must meet manufacturer's specification.

C. Install electric heating cables after piping has passed all hydrostatic pressure testing and before insulation is installed.

D. Install electric heating cables in accordance with IEEE 515.1.

E. Install insulation over piping with electric cables in accordance with Section 230719 "HVAC Piping Insulation."

F. Install warning tape on piping insulation where piping is equipped with electric heating cables.

G. Set field-adjustable switches and circuit-breaker trip ranges.

3.4 CONNECTIONS

A. Ground equipment in accordance with Division 26 sections.

B. Connect wiring in accordance with Division 26 sections

C. Pipe Insulation shall be in accordance with Section 230719 "HVAC Piping Insulation" and is required for a properly operating heat trace system.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Initial start-up and field testing (commissioning) of system shall be performed by factory technician in accordance with Owner's requirements.

B. Contractor to perform the following tests and inspections during installation:

1. Heating cable shall be meggered when received at Project site before installation.
2. Heating cable shall be meggered after installation, but before insulation is installed.
3. Heating cable shall be meggered after insulation is installed.

    a. Insulation resistance must exceed 1,000 megohms at 2,500 V dc.

4. All results must meet manufacturer's specification.
5. Test cables for electrical continuity during installation.
6. Test insulation integrity before energizing.
7. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

C. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.

D. Cables will be considered defective if they do not pass tests and inspections in accordance with manufacturer's testing requirements.

E. Prepare test and inspection reports.

3.6 PROTECTION

A. Protect installed heating cables, including nonheating leads, from damage and moisture ingress during construction.

B. Remove and replace damaged heat-tracing cables.

END OF SECTION

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SECTION 22 05 48
PLUMBING VIBRATION CONTROLS

1. GENERAL

1.1 Coordinate requirements of this specification with all other specifications and trades. Requirements of this specification take precedence over other specification sections. For example, the requirements of this section with regard to pipe supports in mechanical rooms take precedence above the requirements of Section 22 05 29.

1.2 This specification pertains to the furnishing and installation of vibration isolation devices for rotating or reciprocating mechanical equipment and piping and conduit systems attached thereto, and electrical transformers and attached switchgear and conduit systems.

1.3 This work shall include all material and labor required for installation of the resilient mounting and suspension systems, adjusting each mounting system, and measurement of isolator system performance when so requested by the Architect. Specific mounting arrangements for each item of mechanical and electrical equipment shall be as described herein and as indicated by schedules and details on the drawings.

1.4 All vibration isolation equipment except for resilient pipe connectors, including steel framing and reinforcing for concrete inertia bases and including steel rail bases, shall be furnished by Mason Industries or Kinetics Noise Control. A single manufacturer for all vibration isolation equipment in Sections 22 05 48, 23 05 48, and 26 05 48 will be required except as specifically approved in writing by the Architect or by his specific approval of shop drawings or as specified herein. For resilient pipe connectors refer to provisions of this specification that follow.

1.5 SECTION INCLUDES

A. Vibration isolation systems.

1.6 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING GUIDELINES

A. References

B. Submittals

C. Delivery, storage and handling

1.7 ADDITIONAL REQUIREMENTS

A. The Contractor and the vibration isolation manufacturer or his regularly designated and factory authorized representative shall perform the following tasks in addition to the supply and installation of isolation equipment:

1. Obtain from the Architect the approved manufacturer's name, model number, and other necessary identifying data for each item of mechanical and electrical equipment to be resiliently mounted. Coordinate all resilient mounting systems with the exact equipment to be furnished in regard to physical size, isolator locations, weight, rotating speed, etc. Direct contact and cooperation between the vibration isolation device fabricator and the equipment manufacturer will be required.
2. Obtain all necessary data in regard to piping systems which are to be resiliency supported so that proper isolators can be selected. Select piping system isolators for proper coordination with the physical arrangement of pipe lines and with the physical characteristics of the building.
3. Submit shop drawings as required by other portions of this specification. These drawings shall include specification information as follows:

    a. Manufacturer's model number for each isolator, the machine or pipeline to which it is to be applied, and the number of isolators to be furnished for each machine or pipeline.
    b. For steel spring mounts or hangers - Free height, deflected height, solid height, isolator loading, and diameter of spring coil.
    c. For elastomer or glass fiber isolators - Free height, deflected height, and isolator loading.
    d. Dimensional and weight data for concrete inertia bases, steel and rail bases, and details of isolator attachment.

4. Provide on-the-job supervision as required during installation of resiliently mounted equipment and piping to assure that all vibration isolators are installed in strict accordance with normally accepted practices for critical environments.
5. Replace at no extra cost to the Owner any isolators which do not produce the required deflection, are improperly loaded above or below their correct operating height, or which in any way do not produce the required isolation.
6. Cooperate with all other Contractors engaged in this project so that the installation of vibration isolation devices will proceed in a manner that is in the best interests of the Owner.
7. Notify the Architect of any project conditions which affect vibration isolation system installation or performance and which are found to be different from conditions indicated by the drawings or described by the specifications. Should vibration isolation system installation proceed without such notifications any remedial work required to achieve proper isolator performance shall be accomplished by the Contractor at no additional cost to the Owner.

8. Be alert for possible "short-circuiting" of vibration isolation systems by piping supports, electrical connections, temperature control connections, drain lines, building construction, etc., and notify the involved contractor as to these problems or potential problems. Where such situations cannot be easily resolved, notify the Architect so that preventive or remedial action can take place on a timely basis. Any remedial measures required shall be undertaken by the contractor responsible at no additional cost to the Owner.
9. This specification does not include provisions for seismic restraints that might be required by isolations systems due to the geographic location of the project, building codes, or other considerations.

2. PRODUCTS

2.1 VIBRATION ISOLATION SYSTEMS:

1. General:

   a. The vibration isolation systems described herein and identified by type letter designations shall be applied to specific classifications of mechanical and electrical equipment as indicated by Section C of this document.
   b. The minimum static deflection of the isolators for each classification of mechanical or electrical equipment shall be as indicated by Section C of this document or as otherwise indicated herein.

2. Type A Isolation:

   a. The equipment shall be rigidly mounted on a large reinforced concrete inertia base which has length and width dimensions approximately 20% greater than the supported equipment. The inertia base and equipment shall be supported by steel spring vibration isolators. Brackets for the spring isolators shall be located off the sides of the inertia base or integral with the perimeter of the inertia base with the tops of the springs near the vertical center of gravity of the equipment and inertia block; or if the center of gravity is higher than the top of the inertia base, the tops of the springs shall be at the top of the inertia base. The spring isolators shall rest on curbs or pedestals if necessary. There shall be a 2 inch minimum space between the bottom of the inertia base and the top of the housekeeping pad or floor slab when a housekeeping pad is not indicated to be employed.
   b. Concrete inertia bases shall be formed by a welded steel channel frame which incorporates prelocated equipment anchor bolts, and reinforcing bars in each direction welded in place. Concrete shall be standard 150-160 lb/cu.ft. structural concrete. The base thickness shall be determined by the weight requirements but it shall be a minimum of 8% of the longest span between isolators or 6 inches, whichever is greater. For centrifugal and axial fans and centrifugal pumps the inertia base shall have a minimum weight equal to that of the isolated equipment. For reciprocating equipment the inertia base shall have a minimum weight equal to twice the weight of the equipment.

c. Springs shall be of the free standing unhoused type. Horizontal spring stiffness shall not be less than 0.8 of vertical stiffness. Springs shall be selected for reasonably uniform deflection taking into consideration any difference in machine weight at each supporting point, but deflection of each spring shall not be less than that specified for each classification of mechanical equipment. The spring deflection from the point of rated deflection to the point at which the spring is solid shall not be less than 1/2 of the rated static deflection. The yield point of the steel used in the springs shall be sufficiently great so that the springs may be compressed to shorted turns without danger of spring failure. At least two layers of ribbed waffle pattern neoprene pads or equivalent glass fiber pads shall be installed under the base plate of each spring isolator. Springs shall have leveling bolts and proper means for bolting to the machines. To prevent corrosion, springs for outdoor installation shall be galvanized or otherwise coated as approved by the Architect.

3. Type B Isolation:

a. The equipment shall be rigidly mounted on wide flange or channel structural steel members which shall run perpendicular to any support channels or similar members which are an integral portion of the equipment, or which shall be fabricated to form a complete frame for machine mounting. Height saving spring mounting brackets shall be welded to the ends of the structural steel saddle members or to the sides of structural steel frames to attach free standing steel spring isolators. Unless otherwise approved, the depth of the structural steel saddle members or the perimeter members of mounting frames shall be at least one-tenth of the longest frame dimension.
b. Steel spring isolators shall be as specified for Type A isolation.
c. Minimum clearance between the steel base and the housekeeping pad or floor shall be 2 inches.

4. Type C Isolation:

a. The equipment shall be rigidly mounted in a steel frame which is sufficiently stiff so that it may be supported on resilient isolators without distortion of the frame or misalignment of the equipment. If the equipment has an integral frame which is suitably rigid, the resilient isolators may be secured directly to the integral equipment frame or base.
b. Isolators shall be selected on the basis of the required static deflection as scheduled or otherwise indicated, and as follows:

1) Required deflection 0.25 to 0.4 inches - double deflection neoprene-in-shear isolators.
2) Required deflection 0.5 inches and greater - steel spring isolators as specified for the Type A mounting.

c. Isolators shall be selected for reasonably uniform deflection taking into consideration any difference in machine weight at each supporting point, but deflection shall not be less than that specified for each classification of equipment.
d. Minimum clearance between the equipment base and the house keeping pad or floor shall be 2 inches.

5. Type D Isolation:

a. The equipment shall be mounted on resilient "pads". These pads shall be multiple layers of waffle or ribbed neoprene, neoprene and cork sandwich, or precompressed glass fiber with height and stiffness as required to provide the static deflection as scheduled or specified and as required to properly support the load.
b. Pads shall be loaded in accordance with the manufacturer's recommendations and sized to achieve this recommended loading. The equipment weight at each sup porting point shall be considered in selecting pad dimensions along with the recommended loading.

6. Type E Isolation:

a. The equipment shall be suspended with steel spring vibration isolators which are complete with neoprene-in-shear isolators for high frequency noise control. The neoprene-in-shear isolators shall provide static deflection of 0.20 inches minimum. In addition, elastomer washers shall be furnished as necessary to prevent metal-to-metal contact.
b. Hanger rod misalignment of up to 15 degrees relative to vertical shall not cause "short-circuiting" of the isolation components due to metal-to-metal contact.
c. Spring hangers shall utilize free standing springs which are unhoused except for the required partial and open housing assembly. Spring hangers shall be selected for reasonably uniform deflection taking into consideration any difference in machine weight at each supporting point, but deflection of each hanger shall not be less than that specified for each classification of mechanical equipment. The spring deflection from the point of rated deflection to the point at which the spring is solid shall not be less than one-half of the rated static deflection. The yield point of the steel used in the springs shall be sufficiently great so that the springs may be compressed to shorted turns without danger of spring failure.
d. Resilient hangers shall be installed as near as possible to the supporting overhead structure. The machine suspension points shall be in a rigid and heavy portion of the building structure. Suspension of machines from lightweight floor slabs shall be avoided, particularly at the center of structural spans.
e. Suspension rods shall be attached to rigid members of the machine structure. When such attachment points do not exist, a heavy steel framework shall be furnished to support the machine with suspension rods attached to this framework.

7. Type F Isolation:

a. The equipment shall be suspended with double deflection neoprene-in-shear hangers which are complete with elastomer washers as required to prevent metal-to-metal contact.
b. Hangers shall be installed as near as possible to the supporting overhead structure. Suspension points shall be on a rigid portion of both the overhead structure and equipment framework.

8. Type G Isolation:

a. This mounting shall be the same as the Type E mounting except that the suspended machine shall be supported by a concrete inertia base. Suspension rods shall be attached to the concrete base.

9. Type K Isolation (Curb Mounted Roof-top Air Conditioning Machines):

a. The roof-top air conditioning machine shall be mounted on a free standing steel spring isolated rectangular rail (curb) system. The isolation system shall be suitable for outdoor unprotected locations and it shall include a soft and flexible elastomer air and water seal which shall not short circuit the spring isolators. The isolation system shall not allow lateral movement greater than 5/8 inch for wind loads up to 100 miles per hour. Suitable systems of this type are Kinetics Noise Control Type ESR and Mason Industries Type RSC.

10. Type L Isolation (Water Chillers and Similar Equipment):

a. Same as Type C except that steel spring isolators shall employ vertical limit stops with provisions to prevent short circuiting of the limit stops when the springs are loaded normally.

3. EXECUTION

3.1 GENERAL

A. Install in accordance with manufacturer's instructions.

3.2 EXAMINATION

A. Examine areas and equipment to receive vibration isolation control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 VIBRATION-CONTROL DEVICE INSTALLATION

A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Equipment Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

C. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

D. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

E. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

F. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust active height of spring isolators.

C. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.5 ISOLATION OF PIPING SYSTEMS:

A. All piping and rigidly connected devices such as pressure reducing valves which connects to resiliently mounted equipment shall be suspended with resilient hangers or supported by floor mounted isolators for a distance of 100 pipe diameters from the connected machine or within the mechanical equipment room, whichever is the greater distance. The first three supports from the connected machine shall have the same static deflection as indicated for the machine; the next two supports shall have static deflection at least equal to one-half of the static deflection indicated for the machine mounting, and remaining pipe supports shall provide static deflection of 0.35 inches minimum. These remaining isolators may be elastomer.

B. Steel spring hangers shall be as specified for Type E isolation except that a scale shall be attached to the hanger housing to indicate deflection. Elastomer hangers shall be as specified for Type F isolation. Floor mounts shall be free standing steel spring isolators as specified for Type A isolation where static deflection in excess of 0.35 inches is required. Floor mounts, where static deflection of 0.35 inches or less is required, shall be double deflection neoprene-in-shear as specified for Type C isolation.

C. Vertical pipe risers shall be resiliently mounted, preferably with each riser anchored near the center of the run. The risers shall be supported at the anchor points with steel spring or double deflection neoprene-in-shear isolators which provide static deflection of at least 0.35 inches. Isolators for the remainder of each run shall be steel spring type specifically designed to control load shifting due to pipe expansion and contraction. At least 0.35 inches deflection shall be maintained under all conditions.

D. Flexible synthetic rubber connectors shall be used to connect all piping to all isolated equipment. Flexible synthetic rubber connectors shall be fabricated using peroxide cured EPDM synthetic rubber and Kelvar tire cord reinforcement and shall be Mason Industries Safeflex of the most current design. Resilient connectors shall be selected for the pressure rating and temperature rating appropriate for the particular piping and pipe contents. Where synthetic EPDM flexible connectors are not permitted by code due to pipe contents and/or pressures provide swing pipe connectors changing direction a minimum of 3 times before joining isolated equipment. Swing connections should be made within approximately 6 feet of the isolated equipment.

E. Drain connections from isolated equipment to floor drains shall be at least 1" free from drain or use rubber hose.

3.6 ISOLATION OF FRACTIONAL HORSEPOWER EQUIPMENT:

A. All fractional horsepower fans, pumps, etc., which are mounted on or suspended from floors that are not on-grade shall be isolated with neoprene-in-shear isolators furnished by the vibration isolation supplier except where such isolators are furnished as an integral part of the machine.

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SECTION 22 05 53
PLUMBING IDENTIFICATION

1. GENERAL

1.1 SECTION INCLUDES

A. Nameplates.

B. Tags.

C. Pipe Markers.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING GUIDELINES

A. References

B. Related Sections

C. Submittals

D. Quality Assurance

1.3 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Section 01700

B. Record actual locations of tagged valves.

2. PRODUCTS

2.1 NAMEPLATES

A. Equipment Mark Nameplates: Laminated three-layer plastic with engraved black letters (matching equipment mark indicated on drawings) on light contrasting background color, with minimum 3/4 inch high letters.

B. Equipment Nameplates: Factory-applied permanent nameplate indicating the manufacturer's name, model, serial number, temperature and pressure design, and any other data necessary to conform with specified requirements. On equipment installed outdoors, nameplate shall be stamped steel or engrave plastic.

2.2 TAGS

A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter or square.

B. Chart: Typewritten list that is plastic laminated and mounted in mechanical room. Valve list is to coordinate with mechanical piping schematics if provided on plans.

C. Pipe Schematics: Valve numbers are to be labeled on Engineer schematic drawings, plastic laminated and schematic shall be mounted in mechanical room.

2.3 PIPE MARKERS

A. Color: Conform to ASME A13.1.

B. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings; minimum information indicating flow direction arrow and identification of fluid being conveyed.

C. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service. Provide tape with printing which most accurately indicates the type of service of buried pipe.

D. The following abbreviations shall be used on actual labels:

1. CW – Domestic cold water
2. HW – Domestic hot water
3. HWR – Domestic hot water return
4. SW – Sanitary waste
5. SV – Sanitary vent
6. SPD – Sump pump discharge
7. ST – Storm water

3. EXECUTION

3.1 PREPARATION

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

3.2 INSTALLATION

A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

B. Install tags with corrosion resistant chain.

C. Install plastic tape pipe and duct markers in accordance with manufacturer's instructions. Directional arrow tape shall be overlapped to ensure proper adhesion and no peeling of tape in future.

D. Identify air handling units, exhaust fans, chillers, pumps, heat generating, heat rejecting, heat transfer equipment, tanks, and water treatment devices with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.

E. Identify pressure reducing valves, backflow preventers, valves, and meters with tags.

F. Identify control panels and major control components outside panels with plastic nameplates.

G. Identify valves in main and branch piping with tags.

H. Tag automatic controls, instruments, and relays. Key to control schematic.

I. Identify piping, concealed or exposed, with plastic tape pipe markers. For pipes ¾" and smaller, identify piping with tags. Identify service, flow direction, and pressure when applicable, i.e. low pressure steam, high pressure steam. Install in clear view from floor and align with axis of piping. Locate identification not to exceed 15 feet on straight runs including risers and drops, more often in congested areas, adjacent to each valve and tee, at each side of penetration of structure or enclosure, and at each obstruction. Provide a minimum one label per pipe per room. Where pipes are racked, install pipe markers on each pipe in the same location to aid in differentiating each pipe in the rack.

J. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.

1. Provide 14 gauge electrical tracer wire above all underground pipe (plastic or other type of utility piping).

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SECTION 22 07 16
PLUMBING EQUIPMENT INSULATION

1. GENERAL

1.1 SECTION INCLUDES

A. Equipment insulation.

B. Covering.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. REFERENCES.

B. SUBMITTALS

C. QUALITY ASSURANCE

1. Materials: Flame spread/smoke developed rating of 25/50 in accordance with ASTM E84, NFPA 255 and UL 723.

D. DELIVERY, STORAGE AND HANDLING

E. ENVIRONMENTAL REQUIREMENTS

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

2. PRODUCTS

2.1 CELLULAR FOAM

A. Insulation: ASTM C534; flexible, cellular elastomeric, molded or sheet.

1. 'K' ('ksi') value: ASTM C177 or C518; 0.27 at 75 degrees F.
2. Minimum service temperature: -40 degrees F.
3. Maximum service temperature: 220 degrees F.
4. Maximum moisture absorption: ASTM D1056; 1.0 percent (pipe) by volume, 1.0 percent (sheet) by volume.
5. Moisture vapor transmission: ASTM E96; 0.20 perm inches.

6. Maximum flame spread: ASTM E84; 25.
7. Maximum smoke developed: ASTM E84; 50.
8. Connection: Waterproof vapor barrier adhesive.

B. Elastomeric Foam Adhesive: MIL-A-24179A, Type II, Class I, compliant. Air dried, contact adhesive, compatible with insulation. VOC Limit: 50 g/L or less when calculated according to 40 CFR 59, Subpart D.

2.2 JACKETS

A. PVC Plastic

1. Jacket: ASTM C921, One piece molded type fitting covers and sheet material, white color.

a. Minimum Service Temperature: -40 degrees F.
b. Maximum Service Temperature: 150 degrees F.
c. Moisture Vapor Transmission: ASTM E96; 0.002 perm inches.
d. Maximum Flame Spread: ASTM E84; 25.
e. Maximum Smoke Developed: ASTM E84; 50.
f. Thickness: 20 mil.
g. Connections: Brush on welding adhesive or pressure sensitive color matching vinyl tape.

2. Covering Adhesive Mastic: Compatible with insulation. VOC Limit 50 g/L according to 40 CFR 59, Subpart D (EPA Method 24).

3. EXECUTION

3.1 EXAMINATION

A. Verify that piping has been tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

A. Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

B. Install insulation on equipment subsequent to testing and acceptance of tests.

C. Install insulation materials with smooth and even surfaces. Do not use cut pieces or scraps abutting each other.

D. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.

E. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated.

F. Replace damaged insulation which cannot be repaired satisfactorily.

G. Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

H. Painting of cellular foam insulation is not allowed.

I. For equipment in mechanical equipment rooms or in finished spaces, finish with PVC jacket sized for finish covering.

J. Do not insulate over nameplate or ASME stamps. Bevel and seal insulation around such.

K. Install insulation for equipment requiring access for maintenance, repair, or cleaning, in such a manner that it can be easily removed and replaced without damage.

3.3 TOLERANCE

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

3.4 CELLULAR FOAM INSULATION SCHEDULE

Equipment:	Thickness (inches):
Hot water equipment furnished without factory insulation	1-1/2”
Cold systems pump bodies	1-1/2"
Cold flanged strainer bodies.	1-1/2"
Cold system tanks/vessels	1-1/2”
Condensate drain pans	1-1/2”

END OF SECTION

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SECTION 22 07 19
PLUMBING PIPING INSULATION

1. GENERAL

1.1 SECTION INCLUDES

A. Piping insulation.

B. Jackets and accessories.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING GUIDELINES

A. Quality assurance.

1. Materials: Flame spread/smoke developed rating of 25/50 or less in accordance with ASTM E84, NFPA 255, and UL 723.

B. References.

C. Submittals.

D. Operation and maintenance manuals.

E. Project record documents.

F. Environmental requirements

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

2. PRODUCTS

2.1 CELLULAR FOAM

A. Insulation: ASTM C534; flexible, cellular elastomeric, molded or sheet.

1. 'k' ((btu*in)/(hr*ft^2*deg F)) value: ASTM C177 or C518; 0.21 to 0.27 at 75 degrees F mean temperature rating.
2. Minimum Service Temperature: -40 degrees F.
3. Maximum Service Temperature: 220 degrees F.
4. Maximum Moisture Absorption: ASTM C209; 0.2 percent by volume.

5. Moisture Vapor Transmission: ASTM E96; 0.08 perm inches.
6. Maximum Flame Spread: ASTM E84; 25.
7. Maximum Smoke Developed: ASTM E84; 50.
8. Connection: Waterproof vapor barrier adhesive.
9. Provide documentation indicating that product contains no urea formaldehyde.
10. Fittings: Pre-fabricated closed cell fittings of like material and thickness as adjacent pipe insulation.
11. In all exposed finished areas without jacketing, provide white insulation, otherwise use black.

B. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation. MIL-A-24179A, Type II, Class I, compliant. Air dried, contact adhesive, compatible with insulation. VOC Limit: 50 g/L or less when calculated according to 40 CFR 59, Subpart D.

2.2 JACKETS

A. PVC Plastic

1. Jacket: ASTM C921, One piece molded type fitting covers and sheet material, white color.

   a. Minimum Service Temperature: -40 degrees F.
   b. Maximum Service Temperature: 150 degrees F.
   c. Moisture Vapor Transmission: ASTM E96; 0.002 perm inches.
   d. Maximum Flame Spread: ASTM E84; 25.
   e. Maximum Smoke Developed: ASTM E84; 50.
   f. Thickness: 20 mil.
   g. Connections: Brush on welding adhesive or pressure sensitive color matching vinyl tape.

2. Covering Adhesive Mastic: Compatible with insulation. VOC Limit 50 g/L according to 40 CFR 59, Subpart D (EPA Method 24).

3. EXECUTION

3.1 EXAMINATION

A. Verify that piping has been tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

A. Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

B. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance of tests.

C. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete run. Do not use cut pieces or scraps abutting each other.

D. On exposed piping, locate insulation and cover seams in least visible locations. For cellular foam insulation tape ALL visible seams with tape matching insulation color.

E. All new interior piping that is exposed in mechanical rooms, and is within 6'-0" of the finished floor, shall have a PVC jacket installed.

F. Any exposed piping within 6’-0” of the finished floor in an occupied space shall have a PVC jacket installed.

G. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.

H. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.

I. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated.

J. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.

K. Where piping passes through fire walls indicated on the contract drawings, contractor shall install firestopping per firestop manufacturers instructions.

L. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

M. Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

N. Repair damaged sections of existing mechanical insulation, damaged during this construction period. Use insulation of same thickness as existing insulation, install new jacket lapping and sealed over existing.

O. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

P. Wood blocking shall not be used

Q. **Painting of cellular foam insulation is not allowed.**

R. Insulated pipes conveying fluids below ambient temperature:

1. Insulate fittings, joints, flanges, unions strainers, flexible connectors and valves with molded insulation of like material and thickness as adjacent pipe.
2. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations.
3. Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.

S. For insulated pipes conveying fluids above ambient temperature:

1. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe.
2. For hot piping conveying fluids, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.

T. Inserts and Shields:

1. Refer to Section 22 05 29 for additional information.
2. Application: Piping 1 inch diameter or larger.
3. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
4. Insert Location: Between support shield and piping and under the finish jacket.
5. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
6. Provide inserts and/or shields per manufacturer recommendations for cellular foam insulation applications in order to maintain continuous insulation throughout the pipe system. The removal of sections of cellular foam insulation to accommodate pipe supports is not acceptable. Manufacturer products specifically designed for supporting insulation and maintaining the integrity of the insulation system at pipe hanger locations, such Armaflex Armafix Insulation Pipe Hangers, are acceptable.

U. All valves in insulated systems shall have valve stem extensions. Insulation installer shall notify the contractor and Owner if valves without stem extensions are encountered. All valves without stem extensions in areas where stem extensions are required shall be replaced.

V. **Provide insulation clearance and access to valves and fittings in hangers and from structure and other equipment. Insulation shall be continuous through all hangers and supports. Refer to Section 23 07 19.**

3.3 TOLERANCE

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

3.4 CELLULAR FOAM INSULATION SCHEDULE

A. Plumbing Systems

PIPING SYSTEM:	PIPE SIZE:	MIN. THICKNESS:
Domestic Hot Water Supply	1-1/4" & smaller	1"
Domestic Hot Water Supply	1-1/2" & larger	2”
Domestic Hot Water Recirc	1-1/4" & smaller	1"
Domestic Cold Water Supply	All sizes	1"
Soft Cold Water Supply	All sizes	1"
Tempered Domestic Water	All sizes	1”
Tempered Water Recirc	All sizes	1"
Pure Water (Exposed)	6" & smaller	1"
Pure Water (Concealed)	6” & smaller	None
Cold Condensate Drain Piping	6” & smaller	1”
Refrigerant Piping	1-1/2" & smaller	1”
Refrigerant Piping	2" & larger	2”
Roof Drain Bodies	All sizes	1"
Roof Drainage Above Grade	All sizes	1"
Plumbing Vents Within 20 Feet of the Exterior	All sizes	1"
Sanitary Waste Piping Serving Floor Drains/Sinks up to 15’ downstream	All sizes	1”

END OF SECTION

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SECTION 22 10 00
PLUMBING PIPING

1. GENERAL

1.1 SECTION INCLUDES

A. Pipe and pipe fittings.

B. Valves.

C. Sanitary waste and vent piping system.

D. Sump pump discharge piping system.

E. Water piping systems.

F. Storm water piping system.

G. Natural gas piping system.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

1. Valves: Manufacturer's name and pressure rating marked on valve body.

B. References

C. Submittals

D. Operation and maintenance manuals.

E. Project record documents

1. Record actual locations of valves.

F. Delivery, storage, and handling

1.3 REGULATORY REQUIREMENTS

A. Perform Work in accordance with International Plumbing Code.

B. Provide lead-free materials (0.25% lead by weighted average) for applicable potable water meters, materials, piping, valves, fittings, backflow preventers, and other items in accordance with NSF/ANSI 61, including Appendix G.

C. Provide lead-free materials (0.25% lead by weighted average) for applicable potable water faucets, faucet connectors, hoses, supply stops, and other items in accordance with NSF/ANSI 61, including Appendix 9-G.

1.4 ENVIRONMENTAL REQUIREMENTS

A. Do not install underground piping when bedding is wet or frozen.

1.5 EXTRA MATERIALS

A. Provide two repacking kits for each size valve.

2. PRODUCTS

2.1 SANITARY WASTE AND VENT PIPING, BURIED WITHIN 5 FEET OF BUILDING

A. PVC Pipe: ASTM D2665, solid-wall. Cellular core piping is not allowed. (Used only for fluid streams less than 120 Deg. F)

1. Fittings: PVC, ASTM D2665, made to ASTM D3311, DWV patterns and to fit Schedule 40 pipe.
2. Joints: Solvent cement, ASTM D2564; and adhesive purple primer, ASTM F656.

2.2 SANITARY WASTE AND VENT PIPING, ABOVE GRADE

A. PVC Pipe: ASTM D2665, solid-wall. Cellular core piping is not allowed. (Used only for fluid streams less than 120 Deg. F)

1. Fittings: PVC, ASTM D2665, made to ASTM D3311, DWV patterns and to fit Schedule 40 pipe.
2. Joints: Solvent cement, ASTM D2564; and adhesive purple primer, ASTM F656.

2.3 STORM AND OVERFLOW STORM PIPING, ABOVE GRADE

A. PVC Pipe: ASTM D2665, solid-wall. Cellular core piping is not allowed. (Used only for fluid streams less than 120 Deg. F)

1. Fittings: PVC, ASTM D2665, made to ASTM D3311, DWV patterns and to fit Schedule 40 pipe.
2. Joints: Solvent cement, ASTM D2564; and adhesive purple primer, ASTM F656.

2.4 STORM WATER PIPING, BURIED WITHIN 5 FEET OF BUILDING

A. PVC Pipe: ASTM D2665, solid-wall. Cellular core piping is not allowed. (Used only for fluid streams less than 120 Deg. F)

1. Fittings: PVC, ASTM D2665, made to ASTM D3311, DWV patterns and to fit Schedule 40 pipe.
2. Joints: Solvent cement, ASTM D2564; and adhesive purple primer, ASTM F656.

B. Piping shall be a minimum 4” diameter. See drawings for sizes.

2.5 WATER PIPING, BURIED WITHIN 5 FEET OF BUILDING

A. Copper Tubing: ASTM B88, Type K, hard drawn.

1. Fittings: ASME B16.18, cast bronze or ASTM B16.22 wrought copper and bronze.
2. Joints: AWS A5.8, BCuP silver braze.

B. PVC Pipe: AWWA C900; Pressure Class 235 (DR 18); Cast Iron O.D. equivalent; with bell end and elastomeric gasket.

1. Gaskets: ASTM F477, elastomeric seal.

2.6 WATER PIPING, ABOVE GRADE

A. Copper Tubing: ASTM B88, Type L, hard drawn.

1. Fittings: ASME B16.18, cast bronze, or ASME B16.22, wrought copper and bronze.
2. Joints: Lead Free, ASTM B32, Alloy B solder, for piping 1-1/2” and smaller. AWS A5.8, BCuP silver braze, for piping 2” and larger.
3. At contractor’s option, mechanical pressed copper fittings may be used. Joints shall be double pressed type complying with ASME B16.22 and performance criteria of IAPMO PS 117. Sealing elements shall be EPDM and factory installed. Fittings shall be Viega, Mueller or approved equal.

2.7 NATURAL GAS PIPING, ABOVE GRADE

A. Steel Pipe: ASTM A53 or A120, Schedule 40 black.

1. Fittings: ASME B16.3, malleable iron, or ASTM A234, forged steel welding type.
2. Joints: NFPA 54, threaded or welded to ANSI B31.1, ANSI B31.2, ANSI B31.9, ASME Sec 1.

2.8 FLANGES, UNIONS, AND COUPLINGS

A. Pipe Size 2 Inches and Under:

1. Ferrous pipe: 150 psig malleable iron threaded unions.
2. Copper tube and pipe: 150 psig bronze unions with soldered joints.

B. Pipe Size Over 2 Inches:

1. Ferrous pipe: 150 psig forged steel slip-on flanges; 1/16 inch thick preformed neoprene gaskets.

2.9 Copper tube and pipe: 150 psig slip-on bronze flanges; 1/16 inch thick preformed neoprene gaskets.

2.10 DIELECTRIC NIPPLE

A. Standard: IAPMO PS 66.

B. Electroplated steel nipple complying with ASTM F1545.

C. Pressure Rating and Temperature: 300 psig (2070 kPa) at 225 deg F.

D. End Connections: Male threaded.

E. Lining: Inert and noncorrosive, propylene.

2.11 SWING CHECK VALVES

A. Up to and including 2 Inches: Bronze swing disc, 125 psig working pressure.

B. Over 2 Inches: Cast iron body, bronze trim, swing disc, renewable disc and seat, flanged ends.

2.12 BALL VALVES

A. Up to and including 4 inches: Bronze two piece body, lead, free, chrome plated steel full-port ball, teflon seats and stuffing box ring, lever handle.

2.13 BUTTERFLY VALVES

A. Iron, Single-Flange Butterfly Valves with Aluminum-Bronze Disc:

1. Standard: MSS SP-67, Type I.
2. CWP Rating: 200 psig
3. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
4. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
5. Seat: EPDM
6. Stem: One- or two-piece stainless steel.
7. Disc: Aluminum bronze.

2.14 STRAINERS

A. Size 2 inch and Under: Screwed bronze body for 250 psig working pressure, Y pattern with 20-mesh stainless steel perforated screen.

B. Size 2-1/2 inch and larger: Flanged cast iron body for 175 psig working pressure, Y pattern with 3/64 inch stainless steel perforated screen.

2.15 GAS VALVES

A. Gas Cocks 2 Inch and Smaller: 150 psi WOG, bronze body, straightaway pattern, square head, threaded ends.

B. Gas Cocks 2-1/2 Inch and Larger: MSS SP-78; 175 psi, lubricated plug type, semi-steel body, single gland, wrench operated, flanged ends.

C. Solenoid Valves: Aluminum body, 120 volts AC, 60 Hz, Class B continuous duty molded coils; NEMA 4 coil enclosure; electrically opened/electrically closed; dual coils; normally closed; UL and FM approved and labeled.

D. Gas Line Pressure Regulators: Single stage, steel or aluminum jacketed, corrosion-resistant gas pressure regulators; with atmospheric vent, elevation compensator; with threaded ends for 2 inch and smaller, flanged ends for 2-1/2 inch and larger; for inlet and outlet gas pressures, specific gravity, and volume flow indicated.

2.16 CALIBRATED BALANCE VALVES

A. Pre-Set Balance Feature. Valves to be designed to allow Installing Contractor to pre-set balance points for proportional system balance prior to system start-up in accordance with scheduled flow rates.

B. Valve Design and Construction. All valves shall have a calibrated orifice or venturi section, two ¼" threaded pressure tap ports with integral seals, and memory stop to retain the set position. Valves should be rated for 125 psig working pressure and 250 Deg. F maximum operating temperature.

C. Valves shall be selected based on flowrate, not on pipe size dimensions.

D. Preformed Insulation. All vales to be provided with molded insulation to permit access for balance and read-out.

2.17 DRAIN VALVES

A. Equipped with hose adaptor fitting and cap.

3. EXECUTION

3.1 EXAMINATION

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

3.2 PREPARATION

A. Ream pipe and tube ends. Remove burrs.

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

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

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide non-conducting dielectric connections wherever jointing dissimilar metals.

C. Route piping in orderly manner and maintain gradient.

D. Install piping to conserve building space and not interfere with use of space.

E. Group piping whenever practical at common elevations.

F. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

G. Vent pipes shall extend minimum 12” above finish roof line or as required by code.

H. Provide clearance for installation of insulation and access to valves and fittings.

I. Provide access where valves and fittings are not exposed.

J. Establish elevations of buried sanitary and storm piping outside the building to ensure not less than 3 ft of cover.

K. Establish elevations of buried water piping outside the building to ensure not less than 5 ft of cover.

L. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

M. Prepare pipe, fittings, supports, and accessories not prefinished, ready for finish painting.

N. Install bell and spigot pipe with bell end upstream.

O. Install valves with stems upright or horizontal, not inverted.

P. Extend chains on valves with chainwheel operators down to maximum 5-feet above finished floor.

Q. Install strainers in horizontal pipe or in vertical pipe such that flow is downward. Do not install strainers in vertical pipe with flow upward.

R. Install cast iron piping system according to CISPI Handbook.

S. Install copper tubing under building slab according to CDA's "Copper Tube Handbook." Install ball valve directly upstream of each floor slab penetration.

T. Install underground copper tube in PE encasement according to ASTM A 674 or AWWA C105.

U. Install ball valve at all laboratory water connections to fume hoods and other laboratory equipment.

V. Install natural gas shutoff valves at each required piece of equipment. Provide gas regulators as necessary to accommodate equipment pressure requirements. Coordinate with equipment vendor.

3.4 APPLICATION

A. Install unions downstream of valves and at equipment or apparatus connections.

B. Install valves for shut-off and to isolate equipment, part of systems, and vertical risers.

C. Install ball valves for throttling, bypass, or manual flow control services.

D. Provide spring loaded check valves on discharge of water pumps.

E. Provide plug valves in natural gas systems for shut-off service.

F. Provide flow control valves in water recirculating systems where indicated. Balance flow to maintain hot water at all plumbing fixtures.

G. Main Water Service Entry Piping:

1. Install buried water piping in accordance with requirements specified in section 33 11 00.

H. Natural Gas Piping:

1. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
2. Outdoor Piping:

a. Paint piping, fittings, and equipment that are exposed to view from grade with factory-applied paint or protective coating. This includes but is not limited to: exterior metal piping, valves, service regulators, service meters and meter bars, and piping specialties.

1) Alkyd System: MPI EXT 5.1D.

a) Prime Coat: Alkyd anticorrosive metal primer.
b) Intermediate Coat: Exterior alkyd enamel matching topcoat.
c) Topcoat: Exterior alkyd enamel semigloss
d) Color: By Architect

3.5 ERECTION TOLERANCES

A. Establish invert elevations, slopes for drainage to 1/8 inch per foot minimum or as indicated on drawings. Maintain gradients.

B. Slope water piping and arrange to drain at low points.

3.6 PLUMBING PIPING PRESSURE TESTING

A. Test for leaks and defects all new plumbing piping systems and parts of existing systems, which have been altered, extended or repaired. Submit copy of Pipe Pressure Test Log provided in section 22 05 00 for each section of piping tested. Refer to International Plumbing Code for general pipe pressure testing requirements (i.e., test pressure gauges, inspections, etc.).

B. Leave uncovered and unconcealed all new, altered, extended, or replaced piping until it has been tested and approved. Expose all such work for testing that has been covered or concealed before it has been tested and approved.

C. Repair all leaks and defects using new materials and retest all plumbing systems until satisfactory results are obtained.

D. Natural Gas Piping System.

a. Test in accordance with International Fuel Gas Code, NFPA 54, and local utility requirements.

3.7 DISINFECTION OF WATER PIPING SYSTEMS

1. After water systems have been pressure tested and flushed, each system (including distribution system to building) shall be cleaned and disinfected per AWWA C651. Note that procedures shall require two (2) consecutive sets of acceptable samples taken at least 24 hours apart.
2. Take samples no sooner than 24 hours after flushing, from outlets and from water entry per AWWA 651, and analyze in accordance with AWWA C651.
3. Samples shall be subject to bacteriological testing by a recognized 3rd party testing agency. Send test reports to Owner for review. If unsatisfactory bacteriological results are found, the system shall be disinfected and retested again until satisfactory results are obtained.

3.8 SERVICE CONNECTIONS

A. Provide new sanitary and storm sewer services. Before commencing work check invert elevations required for sewer connections, confirm inverts and ensure that these can be properly connected with slope for drainage and cover to avoid freezing.

B. Provide new water service complete with approved backflow preventer and water meter with by-pass valves.

1. Provide sleeve in wall for service main and seal at wall/floor with mechanical sleeve seals. Anchor service main inside to concrete wall/floor.

END OF SECTION

SECTION 22 11 19
PLUMBING SPECIALTIES

1. GENERAL

1.1 SECTION INCLUDES

A. Backflow preventers.

B. Expansion tanks.

C. Cleanouts.

D. Water hammer arresters.

E. Floor drains and floor sinks.

F. Hose bibs.

G. Installation requirements of other plumbing specialties scheduled in Plumbing Specialties Schedule.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

B. References

C. Submittals

D. Operation and maintenance manuals.

E. Project record documents

F. Delivery, storage, and handling

1.3 REGULATORY REQUIREMENTS

A. Perform Work in accordance with International Plumbing Code.

B. Provide lead-free materials (0.25% lead by weighted average) for applicable potable water meters, materials, piping, valves, fittings, backflow preventers, and other items in accordance with NSF/ANSI 61, including Appendix G.

C. Provide lead-free materials (0.25% lead by weighted average) for applicable potable water faucets, faucet connectors, hoses, supply stops, and other items in accordance with NSF/ANSI 61, including Appendix 9-G.

1.4 BACKFLOW PREVENTERS

A. Refer to Plumbing Specialties Schedule on drawings for required product information.

B. Reduced-Pressure-Principle Backflow Preventers

1. Standard: ASSE 1013.
2. Operation: Continuous-pressure applications.
3. Body: Bronze for 3” and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for 4” and larger.
4. End Connections: Threaded for NPS 3 and smaller; flanged for NPS 4” and larger.
5. Accessories:

    a. Valves: Ball type with threaded ends on inlet and outlet of NPS 3” and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 4” and larger.
    b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

6. Manufacturers: Watts or Zurn/Wilkins.

C. Double-Check Backflow-Prevention Assemblies:

1. Standard: ASSE 1015.
2. Operation: Continuous-pressure applications, unless otherwise indicated.
3. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
4. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
5. Accessories:

    a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.

6. Manufacturers: Watts or Zurn/Wilkins.

1.5 DIAPHRAGM TYPE EXPANSION TANKS

A. Refer to Plumbing Specialties Schedule on drawings for required product information.

B. Construction:

1. Shell: High Strength Steel
2. Diaphragm: Heavy Duty Butyl NSF/ANSI 61
3. Liner: Antimicrobial
4. System Connection: Stainless Steel
5. Water Circulator: Patented Turbulator
6. Air Valve: Projection Welded
7. Air Valve Cap
8. Factory Precharge: 50 psig.

C. Performance:

1. Max. Operating Temperature: 200 deg F
2. Max. Working Pressure: 150 psig

D. Manufacturer/Model: Amtrol Therma-X-Trol Series or equivalent.

1.6 CLEANOUTS

A. Exterior Surfaced Areas: Round or Square cast nickel bronze access frame and non-skid cover.

B. Interior Finished Floor Areas: cast iron body and frame, nickel bronze top to accommodate the following floor finishes as required:

1. Exposed rim type with recess to receive tarrazzo or resilient floor finish.
2. Exposed finish type with standard mill finish.
3. Exposed flush type with standard scored or abrasive finish.
4. Concealed undercarpet flush type with mill finish and carpet marker.

C. Interior Finished Wall Areas: Line type with cast iron body and round gasket cover and round stainless steel access cover secured with machine screw.

D. Interior Unfinished Accessible Areas: Caulked or threaded type.

1.7 WATER HAMMER ARRESTERS

A. Standard: ASSE 1010 or PDI-WH 201.

B. Type: Metal bellows or copper tube with piston.

C. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F. Size per manufacturer recommendations.

1.8 WATER HAMMER ARRESTERS

A. Standard: ASSE 1010 or PDI-WH 201.

B. Type: Diaphragm.

C. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

1.9 OTHER SPECIALTIES

A. Refer to Plumbing Specialties Schedule for required product information.

2. EXECUTION

2.1 PREPARATION

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

2.2 INSTALLATION

A. All Plumbing Specialties:

1. Install in accordance with manufacturer's instructions.

B. Cleanouts:

1. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Ensure clearance at cleanout for rodding of drainage system.
2. Encase exterior cleanouts in concrete flush with grade.

C. Backflow Preventers:

1. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to either building exterior or floor drain (coordinate with plans). Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.

2. If equipped with a relief valve, pipe relief from backflow preventers to nearest drain. Piping diameter of drain piping shall match outlet diameter of air gap fitting.
3. Provide final certification for all testable backflow preventers, after installation, by certified cross connection device tester. Submit copy of successful test to Owner's Representative.

D. Water Hammer Arrestors:

1. Install water hammer arrestors complete with accessible isolation valve according to PDI-WH 201 and as shown on drawings.

E. Floor Drains / Floor Sinks:

1. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
2. Position floor drains for easy access and maintenance.
3. Unless dimensioned on drawings, location of drains shown on plans are approximate. Installing contractor shall be responsible for coordinating final location with other trades to ensure proper coordination with other building elements including but not limited to: structural members (above/below grade), owner-furnished equipment, walls, and bathroom partitions. Upon identifying a coordination conflict, the contractor shall notify the Engineer of Record by way of RFI with suggested location for drain and obtain approval of new location. No additional compensation shall be provided by Owner for lack of coordination.
4. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:

    a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
    b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
    c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.

5. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
6. Install barrier-type trap seal protection device in all floor drains and sinks, unless noted otherwise on plans.
7. Provide deep seal traps in all locations when possible.

2.3 TESTING

A. Test and certify all backflow preventers for proper operation. Testing agent shall be Grade VI Water Operator.

1. Test shall be completed within 30 days of installation or Substantial Completion, whichever is later.

END OF SECTION

SECTION 22 13 43 – FACILITY PACKAGED SEWAGE PUMPING STATIONS

1. GENERAL

1.1 SECTION INCLUDES

A. Wet-well, packaged pumping stations with submersible grinder sewage pumps

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

A. References.

B. Performance requirements.

1. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within ± 10 percent of scheduled performance and published operating curve.

C. Submittals.

1. Detailed specifications.
2. Drawings with dimensions.
3. Parts List.
4. Pumps :

a. Name of manufacturer.
b. Type and model.
c. Rotative speed.
d. Size of suction nozzle.
e. Size of discharge nozzle.
f. Complete performance curves showing capacity versus head,
g. NPSH required, pump and wire-to-water efficiency, and bhp.

5. Motors:

a. Name of manufacturer.
b. Type and model.
c. Type of bearings and lubrication.
d. Rated size of motor hp.
e. Temperature rating.
f. Full load rotative speed.
g. Efficiency at full, 3/4, and 1/2 load.
h. Full load current.

i. Locked rotor current.

6. Control Panel and components.

a. Name of manufacturer.
b. Type and model.
c. Dimensions and net weight of complete panel.
d. Overcurrent characteristics and details of motor control.

7. Operation and maintenance manuals for each type and size pump specified.

D. Operation and maintenance data.

E. Qualifications.

F. Delivery, storage and handling.

G. Extra materials.

1. Provide one set of mechanical seals and gaskets for each pump.

H. Warranty

1. Products included in this specification section shall have a 1-year warranty.

2. PRODUCTS

A. WET-WELL, PACKAGED PUMPING STATIONS WITH SUBMERSIBLE GRINDER SEWAGE PUMPS

1. See pump schedule on drawings for requirements.
2. Description: Factory fabricated, assembled, and tested with wet well for sewage pumps and collection of sanitary sewage and with suspended sewage pumps, controls, and accessories.
3. PU-6 and PU-7 REQUIREMENTS:

a. Scope: Furnish Stancor SG-500 or approved equivalent electric submersible grinder type wastewater pump(s) capable of delivering the scheduled design flow requirements. Pump shall include a 2” discharge. Each pump unit shall have 33_feet of power cable. The pump assembly shall have CSA U.S. 214705 approval.
b. Pump Design: The pump(s) shall be designed to handle, without clogging, clean water, contaminated water, wastewater effluent, storm water, and other similar corrosive liquids which may contain small solids. The pump shall have integrated feet allowing it to stand on a hard bottom wet well.

c. Pump Construction: Major pump components shall be of FC-20 Cast Iron with smooth surfaces devoid of porosity or other irregularities. All exposed fasteners shall be AISI type 316 stainless steel. Critical mating surfaces where a watertight seal is required shall be machined and fitted with NBR o-rings. Sealing will be the result of controlled compression of rubber o-rings without requiring a specific torque on fasteners to accomplish sealing. Rectangular cross sectioned gaskets requiring specific fastener torque to achieve compression shall not be considered adequate or equal. No secondary sealing compounds shall be used or required.

1) Impeller: The impeller shall be a non-clogging, dynamically balanced, semi-open grinder impeller with shredding ring design, capable of passing a 4 mm diameter spherical solid. The impeller shall have a precision machined slip fit onto the motor shaft and drive key, and shall be fastened to the shaft by a stainless steel impeller nut. The use of adjustable bottom plates to maintain efficiency shall not be considered equal.
2) Pump Volute: The pump volute shall be a single piece design with vertical discharge. Passages shall be smooth and large enough to pass any solids which may enter the impeller. Discharge flange design shall permit attachment to standard 2 " NPT pipe fittings.
3) Grinder Mechanism: The grinder mechanism shall consist of two circular, hardened cutter elements, one rotating and one stationary. The cutter material shall be of high Chrome Alloy with a hardness of Rockwell C 55-58. The rotating element shall be secured to the end of the pump shaft directly below the impeller by a stainless steel bolt which is mechanically prevented from loosening by a stainless steel nut. It shall be keyed to the impeller so that it rotates with the motor. The stationary element shall be secured to the cutter bracket and positioned so that it is concentric to and aligned with the rotating element. The stationary elements shall incorporate a vertical spline pattern at the grinding interface to create a shearing and cutting action between the elements as the rotating cutter spins. The rotating cutter shall incorporate an integrated solids deflector to prevent items such as plastic bags from covering the grinder assembly and starving the pump. All wastewater being pumped by the impeller shall be drawn through the grinder mechanism by the natural suction of the pump impeller and reduced to a particle size approximately 1/8 inch. The grinder mechanism shall not require routine adjustments throughout the life of the grinder assembly.
4) Shaft & Rotating Assembly: The common motor/pump shaft shall be of Stainless Steel-410 material that is in contact with pump's mechanical seals and shall have a polished finish and accurately machined shoulders to accommodate bearings, seals and impeller. Carbon steel shafts shall not be considered adequate or equal. The rotating assembly (impeller, shaft and rotor) shall be dynamically balanced such that undue vibration or other unsatisfactory characteristics will not result when the pump is in operation.
5) Triple Seal System: Each pump shall be equipped with a tandem mechanical shaft seal system consisting of two independent seal assemblies with a common spring between them and a radial lip seal; providing three complete levels of sealing between the pump wet end and the motor. The mechanical seals shall

operate in an oil filled chamber which is completely separate from the motor chamber. The seal faces shall be SiC/Sic for the lower seal and Carbon/Ceramic for the upper seal. Metallic components of the mechanical seal shall be constructed of 300 series stainless steel. The seal system shall not rely upon the pumped media for lubrication and shall not be damaged when the pump is run dry. A readily accessible inspection screw shall be provided for inspecting the condition of the seal chamber oil during routine maintenance.

6) Bearings: The pump shaft shall rotate on permanently lubricated, greased bearings. The upper bearing shall be a single row deep grooved ball bearing. The lower bearing shall be a heavy duty single row, deep grooved ball bearing. Upper and lower bearings shall be of sufficient size and properly spaced to transfer all radial and axial loads to the pump housing and minimize shaft deflection. B-10 bearing life shall be a minimum of 30k hr at BEP. Pump designs utilizing other than ball bearings, or those requiring supplemental guide bushings for the shaft or impeller shall not be considered acceptable.
7) Motor: The motor housing shall be FC-20 Cast Iron and the top cover of FC-20 Cast Iron. The motor shall be of the squirrel-cage induction design with copper windings, housed in an air filled, water tight chamber. The motor shall be capable of continuous submerged operation under water to a depth of 33 feet. The stator windings and stator leads shall be insulated with moisture resistant Class F insulation rated for 155 deg C (311 deg F). The motor shall be capable of operating continuously, submerged in liquid of 40 deg C (104 deg F) without overheating. The motor shall be capable of handling up to 10 evenly spaced starts per hour. All motors shall have a voltage tolerance of +/- 10% from nominal name plate rating.
8) Power Cable: The power cable shall be sized according to NEC and CSA standards and shall be of sufficient length to reach the junction box without requiring splices. The outer jacket of the cable shall be oil and water resistant thermoplastic elastomer. The power cable shall be fitted to the motor using an epoxy potted water tight cable entry system with a rubber grommet as the secondary seal and strain relief.

d. Factory provided rail system to allow for removal of pumps from tanks. Refer to Tank details on drawings for more information. Rail system to include (2) 2" cast iron discharge elbows with with internal check valves to allow removal of pump without disconnection of pipe.
e. Stancor m/n CB2002 3-phase duplex pump control panel.

1) UL 508A and UL 698A certified.
2) 16x14x7 NEMA 4X polycarbonate enclosure
3) IEC motor contactor.
4) Multi-tap transformer.
5) Motor protective switch (overload)
6) Alternator.
7) Green pump run indicator lights.
8) Alarm/control fuse.
9) Float switch terminal block.

10) Input power terminal block.
11) Ground lugs.
12) HOA (hand/off/auto) swtiches.
13) Standard alarm package:

a) High level relay for dry contacts
b) Indicator light for visual check
c) Sonalert audible alarm
d) Exterior alarm test with silence
e) Horn silence relay

14) Provide the following options:

a) High-water alarm
b) Mechanical float switches 20'-120' cords
c) Dry contacts for remote alarm signal
d) Door-mounted interlocking disconnects
e) High alarm dry contact

15) Control Sequence of Operation: Cycle each sewage pump on and off automatically to maintain wet-well sewage level. Automatic control operates both pumps in parallel if wet-well level rises above starting point of low-level pump, until shutoff level is reached. Automatic alternator, with manual disconnect switch, changes sequence of lead-lag sewage pumps at completion of each pumping cycle.
16) Stancor m/n FLOAT 741-009-1-XXX mechanically-activated, narrow-angle float switch designed to activate pump control panels and alarms.

a) Cable: flexible 18 gauge 2 conductor (UL, CSA) SJOW, water-resistant
b) Float: 2.74 inch diameter x 4.83 inch long high impact, corrosion resistant, polypropylene housing for use in sewage and water up to 140 deg F.
c) Electrical: 5 amp, 125/250 VAC, 50/60Hz

4. PU-8 and PU-9 REQUIREMENTS:

a. Scope: Furnish Stancor SG-750 or approved equivalent stainless steel electric submersible non-clog wastewater pump(s) capable of delivering the scheduled design flow requirements. Pump shall include a 2" discharge. Each pump unit shall have 33_feet of power cable. The pump assembly shall have CSA U.S. 214705 approval.
b. Pump Design: The pump(s) shall be designed to handle, without clogging, clean water, contaminated water, wastewater effluent, storm water, and other similar corrosive liquids which may contain small solids. The pump shall have integrated feet allowing it to stand on a hard bottom wet well. The pump shall also be capable of mounting on a Guide Rail System allowing the pump to be removed from the wet well without disturbing the discharge piping or requiring personnel to enter the wet well.

c. Pump Construction: Major pump components shall be of AISI type 316 stainless steel with smooth surfaces devoid of porosity or other irregularities. All exposed fasteners shall be AISI type 316 stainless steel. Critical mating surfaces where a watertight seal is required shall be machined and fitted with FKM o-rings. Sealing will be the result of controlled compression of rubber o-rings without requiring a specific torque on fasteners to accomplish sealing. Rectangular cross sectioned gaskets requiring specific fastener torque to achieve compression shall not be considered adequate or equal. No secondary sealing compounds shall be used or required.

1) Impeller: The impeller shall be a non-clogging, dynamically balanced, vortex design, capable of passing a 45mm diameter spherical solid. The impeller shall have a precision machined slip fit onto the motor shaft and drive key, and shall be fastened to the shaft by a stainless steel impeller nut. The use of adjustable bottom plates to maintain efficiency shall not be considered equal.
2) Pump Volute: The pump volute shall be a single piece design with vertical discharge. Passages shall be smooth and large enough to pass any solids which may enter the impeller. Volute inlet opening shall be 65mm. Flanged Discharge design shall permit attachment to standard 3” or 4” NPT pipe fittings or optional guide rail system.
3) Shaft & Rotating Assembly: The common motor/pump shaft shall be of AISI type 316 stainless steel material that is in contact with pump’s mechanical seals and shall have a polished finish and accurately machined shoulders to accommodate bearings, seals and impeller. Carbon steel shafts shall not be considered adequate or equal. The rotating assembly (impeller, shaft and rotor) shall be dynamically balanced such that undue vibration or other unsatisfactory characteristics will not result when the pump is in operation.
4) Triple Seal System: Each pump shall be equipped with a tandem mechanical shaft seal system consisting of two independent seal assemblies with a common spring between them and a radial lip seal; providing three complete levels of sealing between the pump wet end and the motor. The mechanical seals shall operate in an oil filled chamber which is completely separate from the motor chamber. The seal faces shall be SiC/Sic for the lower seal and Carbon/Ceramic for the upper seal. Metallic components of the mechanical seal shall be constructed of 300 series stainless steel. The seal system shall not rely upon the pumped media for lubrication and shall not be damaged when the pump is run dry. A readily accessible inspection screw shall be provided for inspecting the condition of the seal chamber oil during routine maintenance.
5) Bearings: The pump shaft shall rotate on permanently lubricated, greased bearings. The upper bearing shall be a single row deep grooved ball bearing. The lower bearing shall be a heavy duty single row, deep grooved ball bearing. Upper and lower bearings shall be of sufficient size and properly spaced to transfer all radial and axial loads to the pump housing and minimize shaft deflection. B-10 bearing life shall be a minimum of 30k hr at BEP. Pump designs utilizing other than ball bearings, or those requiring supplemental guide bushings for the shaft or impeller shall not be considered acceptable.
6) Motor: The motor housing and top cover shall be AISI type 316 stainless steel. The motor shall be of the squirrel-cage induction design with copper windings,

housed in an air filled, water tight chamber. The motor shall be capable of continuous submerged operation under water to a depth of 33 feet. The stator windings and stator leads shall be insulated with moisture resistant Class B insulation rated for 130 deg C (266 deg F). The motor shall be capable of operating continuously, submerged in liquid of 40deg C (104 deg F) without overheating. The motor shall be capable of handling up to 10 evenly spaced starts per hour. All motors shall have a voltage tolerance of +/- 10% from nominal name plate rating.

7) Power Cable: The power cable shall be sized according to NEC and CSA standards and shall be of sufficient length to reach the junction box without requiring splices. The outer jacket of the cable shall be oil and water resistant thermoplastic elastomer. The power cable shall be fitted to the motor using an epoxy potted water tight cable entry system with a rubber grommet as the secondary seal and strain relief.

d. Factory provided rail system to allow for removal of pumps from tanks. Refer to Tank details on drawings for more information. Rail system to include (2) 2" cast iron discharge elbows with with internal check valves to allow removal of pump without disconnection of pipe.

e. Stancor m/n CB2000 3-phase simplex pump control panels. One panel for each pump.

1) UL 508A and UL 698A certified.
2) 14x7x2 NEMA 4X polycarbonate enclosure
3) IEC motor contactor.
4) Multi-tap transformer.
5) Motor protective switch (overload)
6) Green pump run indicator lights.
7) Alarm/control fuse.
8) Float switch terminal block.
9) Input power terminal block.
10) Ground lugs.
11) HOA (hand/off/auto) swtiches.
12) Standard alarm package:

a) Indicator light for visual check
b) Sonalert audible alarm
c) Exterior alarm test with silence
d) Horn silence relay

13) Provide the following options:

a) High-water alarm with red LED light, buzzer and test-silence switch.
b) Mechanical float switches with 20'-60' cords
c) Dry contacts for remote alarm signal
d) High alarm dry contact

14) Control Sequence of Operation: Cycle pump on and off automatically to maintain wet-well sewage level. Automatic control operates pump if wet-well level rises above starting point of low-level pump, until shutoff level is reached.
15) Stancor m/n FLOAT 741-009-1-XXX mechanically-activated, narrow-angle float switch designed to activate pump control panels and alarms.

a) Cable: flexible 18 gauge 2 conductor (UL, CSA) SJOW, water-resistant
b) Float: 2.74 inch diameter x 4.83 inch long high impact, corrosion resistant, polypropylene housing for use in sewage and water up to 140 deg F.
c) Electrical: 5 amp, 125/250 VAC, 50/60Hz

5. Biowaste Tanks:

a. Description: Precast vault structure and lid. See Biowaste Tank details on drawings for more information.
b. 5600 gal tank made of ASTM C478 4000 PSI concrete minimum with 0.45 maximum water/cementitious materials ratio.

1) Reinforcing fabric: ASTM A 1064/A 1064M, steel, welded wire fabric, plain.
2) Reinforcing bars: ASTM A 615/A 615M, Grade 60 deformed steel.
3) ConShield with CONTINT shall be added to all precast and cast-in-place manholes in accordance with manufacturer's recommendations.

a) Cast-in-place concrete invert fill and collars inside the manhole shall contain ConShield with CONTINT per manufacturer's recommendation.

c. Base section:

1) Floor slab: 8 inch thick, unless otherwise indicated on drawings.
2) Walls: 6 inch thick, unless otherwise indicated on drawings.
3) Base riser section: 6 inch thick, unless otherwise indicated on drawings.

d. Riser section:

1) 48 inch diameter unless otherwise indicated on drawings, with 6 inch thick walls.

e. Top section: Concentric cone, eccentric cone, or flat slab type, as indicated on drawings.

1) Top of cone to match grade rings.

f. Grade rings: Reinforced concrete rings, 4 to 9 inches thick.
g. Gasket: O-ring, double ring, or preformed bitumastic sealant.

h. Steps: Steel reinforced polypropylene plastic steps per ASTM 4101, cast into base, riser and top sections at 12 inches intervals.
i. Frame and cover: ASTM A48, Class 35 gray iron.

1) Frame size: 24 inch inside diameter, by 9 inch riser with 4 inch width flange.
2) Cover: 26 inch diameter, indented top design, with lettering “SANITARY SEWER” cast into cover.

j. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
k. Pipe connectors: ASTM C923, resilient type.

1) Provide “boot” type nitrile rubber connections at locations indicated on Drawings.

l. Interior of tank to be coated with Duralkote 500 epoxy coating applied in field after installation.

3. EXECUTION

3.1 PREPARATION

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

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.

C. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings.

D. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

3.3 START-UP AND COMMISSIONING

A. Before and after start-up, perform the following preventative maintenance operations and checks:

1. Lubricate bearings.

2. After pump is started, check for proper rotation, proper mechanical operation and motor load to ensure that pump is not overloaded. Close pump balancing valve as required to bring pump motor load within motor nameplate data.
3. Check pumps to ensure it is not air bound or cavitating.
4. After completing start-up, replace pump strainer with permanent strainer.

B. Engage a factory-authorized service representative to perform startup service.

1) Complete installation and startup checks according to manufacturer's written instructions.
2) Adjust pump, accessory, and control settings, and safety and alarm devices.

END OF SECTION

SECTION 22 21 23
PLUMBING PUMPS

1. GENERAL

1.1 SECTION INCLUDES

A. In-line wet rotor circulation pumps for potable water systems.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

A. References.

B. Performance requirements.

1. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within ± 10 percent of scheduled performance and published operating curve.

C. Submittals.

D. Operation and maintenance data.

E. Qualifications.

F. Delivery, storage and handling.

G. Extra materials.

2. PRODUCTS

A. IN-LINE WET ROTOR CIRCULATION PUMPS FOR POTABLE WATER SYSTEMS

B. See Plumbing Pumps Schedule on drawings for performance requirements.

C. The contractor shall furnish and install in-line circulating pumps as illustrated on the plans and in accordance with the following specifications:

1. The pumps shall be a wet rotor inline pump, in cast iron or lead free stainless steel body construction specifically designed for quiet operation. Suitable standard operations at

230° F and 175 PSIG working pressure. The pump internals shall be capable of being serviced without disturbing piping connections.

2. The pump internals shall be capable of being serviced without disturbing piping connections.
3. Pump shall be equipped with a water-tight seal to prevent leakage.
4. Pump volute shall be of a cast iron design for heating systems or lead free stainless steel for domestic water systems. The connection style on the cast iron and stainless steel pumps shall be flanged.
5. Flange to Flange dimension shall be standard Bell & Gossett booster sizes such as 6-3/8", 8-1/2", 11-1/2", and 12". Flange dimensions shall be HVAC industry standard 2 or 4 bolts sizes.
6. Motor shall be a synchronous, permanent-magnet (PM) motor and tested with the pump as one unit. Conventional induction motors will not be acceptable.
7. Each motor shall have an Integrated Variable Frequency Drive tested as one unit by the manufacturer.
8. Integrated motor protection shall be verified by UL to protect the pump against over/under voltage, over temperature of motor and/or electronics, over current, locked rotor and dry run (no load condition).
9. Pump shall have MODBUS or BACnet connections built into the VFD as standard options.
10. Analog inputs, such as 0-10V and 4-20mA, are standard inputs built into the VFD.
11. Pumps shall be UL 778 listed and bear the UL Listed Mark for USA and Canada with on-board thermal overload protection.
12. Pumps shall be UL 778 listed and bear the UL Listing Mark for USA and Canada with on-board thermal overload protection.
13. Each pump shall be factory performance tested before shipment.

3. EXECUTION

3.1 PREPARATION

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

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.

C. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings.

D. Provide line sized shut-off valve and pump suction fitting flexible connection on pump suction, and line sized soft seat check valve and balancing valve on pump discharge.

E. Install valves that are the same size as piping connected to pumps.

F. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

3.3 START-UP AND COMMISSIONING

A. Start-up pump in accordance to manufacturer written instructions.

B. Do not start pump until the system has been filled and vented. Air should be vented from the system by means of an air vent located at a high point in the system. The system must be completely vented prior to pump operation. Do not run circulators dry. Pump operation without water circulation could result in pump and motor damage.

C. Coordinate pump testing, adjusting and balancing with Balancing Contractor. Complete additional preliminary work required by Balancing Contractor.

END OF SECTION

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SECTION 22 30 00 - PLUMBING EQUIPMENT

1. GENERAL

1.1 SECTION INCLUDES

A. Water heaters

B. Thermal mixing valves.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING GUIDELINES

A. References

B. Submittals

1.3 QUALITY ASSURANCE

A. See Section 22 05 00.

B. Perform Work in accordance with State and Local standards.

C. Ensure products and installations of specified products are in conformance with recommendations and requirements of the following organizations:

1. National Sanitation Foundation (NSF).
2. American Society of Mechanical Engineers (ASME).
3. National Board of Boiler and Pressure Vessel Inspectors (NBBPVI).
4. National Electrical Manufacturers' Association (NEMA).
5. Underwriters Laboratories (UL).

2. PRODUCTS

2.1 Refer to Plumbing Equipment Schedules for performance requirements.

2.2 WATER HEATER

A. The water heater shall be a Lochinvar Shield series or approved equal having a maximum input rating and recovery capacity equal to what is shown in schedule on drawings and shall be operated on Natural Gas. The water heater shall be capable of full modulation firing down to 20% of rated input with a 5:1 turndown ratio

B. The water heater shall consist of a direct fired Stainless Steel heat exchanger mounted on top of a glass lined storage tank in a fashion that will reduce the amount of scale build-up that is known to reduce efficiency. The water heater shall have no visible pipes that connect the heat exchanger to the storage tank. There shall be no banding material, bolts, gaskets or "O" rings in the construction of the heat exchanger header. The Stainless Steel combustion chamber shall be designed to drain condensation to the bottom of the heat exchanger assembly. A built-in trap shall allow condensation to drain from the heat exchanger assembly. The water heater shall carry a three (3) year heat exchanger and tank warranty and a one (1) year parts warranty.

C. The tank shall have a working pressure of 150 psi. The tank shall be glass lined and fired to 1600°F to ensure a molecular fusing of glass and steel. The tank shall be completely encased in high density insulation of sufficient thickness to meet the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard. The tank shall be fitted with a brass drain valve.

D. The water heater shall be certified and listed by C.S.A. International under the latest edition of the harmonized ANSI Z21.10.3 test standard for the US and Canada. The water heater shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 90.1 standard. The water heater shall be certified for indoor installation. The water heater's efficiency shall be verified through third party testing by AHRI and listed in the AHRI Certification Directory.

E. The water heater shall be constructed with a heavy gauge steel jacket assembly, primed and pre-painted on both sides. The combustion chamber shall be sealed and completely enclosed, independent of the outer jacket assembly, so that integrity of the outer jacket does not affect a proper seal. A burner/flame observation port shall be provided. The burner shall be a premix design and constructed of high temperature stainless steel with a woven metal fiber outer covering to provide modulating firing rates. The water heater shall be supplied with a gas valve designed with negative pressure regulation and be equipped with a variable speed blower system, to precisely control the fuel/air mixture to provide modulating firing rates for maximum efficiency. The water heater shall operate in a safe condition at a de-rated output with gas supply pressures as low as 4 inches of water column.

F. The water heater shall utilize a 24 VAC control circuit and components. The control system shall have an electronic display for setup, status and diagnostics. All electronic circuitry shall be easily accessed and serviceable from the front of the jacket. The water heater shall be equipped with; a circulating pump; high limit temperature control; ASME certified temperature and pressure relief valve; inlet & outlet water temperature sensors; flue temperature sensor; runtime contacts; alarm contacts; low water flow protection, contacts for louvers, security protection, adjustable pump delay, enable/disable contacts and built-in freeze protection. The control shall have optional capability to communicate via Modbus or BACnet protocol and capability for optional CON-X-US remote connectivity. The manufacturer shall verify proper operation of the burner, all controls and the heat exchanger by connection to water and venting for a factory operation test prior to shipping.

G. The water heater shall feature the smart control platform with pump delay, freeze protection, pump exercise and Start-Up Wizard operating with an LCD display and soft key pad. The water heater shall be equipped with an eight foot power cord. Supply voltage shall be 120 volt / 60 hertz / single phase.

H. The water heater shall be installed and vented with a direct vent vertical system with a vertical roof top termination of both the vent and combustion air. The flue shall be CPVC, Polypropylene or Stainless Steel sealed vent material terminating at the roof top with the manufacturers specified vent termination. A separate pipe shall supply combustion air directly to the water heater from the outside. The air inlet pipe may be PVC, CPVC, Polypropylene, ABS, Galvanized, Dryer Vent, or Stainless Steel sealed pipe. The air inlet must terminate on the roof top with the manufacturer's specified air inlet cap. The total combined air intake length shall not exceed 150 equivalent feet. The total combined exhaust venting length shall not exceed 150 equivalent feet. Foam Core pipe is not an approved material for exhaust piping.

I. The water heater shall be approved for 180°F operation. The water heater shall have an independent laboratory rating for Oxides of Nitrogen (NOx) of 20 ppm or less, corrected to 3% O2. The water heater shall operate at altitudes up to 4,500 feet above sea level without additional parts or adjustments.

J. Maximum unit dimensions shall be: Width 34 inches and Height 80 inches. Maximum unit weight shall be 850 pounds.

K. The Firing Control System shall be M9, Direct Spark Ignition with Electronic Supervision.

2.3 THERMAL MIXING VALVES

A. Refer to Plumbing Equipment Schedule for performance requirements.

B. Manufacturer: Subject to compliance with scheduled requirements, provide product by one of the following:

1. Powers
2. Armstrong International, Inc.
3. Leonard Valve Company
4. Or equivalent.

C. Digital mixing valve with check stops, integral RTD sensor, return piping assembly.

D. 1-1/4" inlets, 1-1/2" outlet, 1" return

E. 0.25 GPM minimum flow capacity

F. Maximum operating pressure: 125 PSIG.

G. +/- 2 deg F water temperature control per ASSE 1017.

H. Automatic hot/cold water shutoff upon cold/ho water inlet supply failure.

I. User programmable setpoint range between 65 deg F and 180 deg F.

J. UL listed control box.

K. UL listed 120V plug in power supply with 6’ cord.

L. Factory assembled and tested.

3. EXECUTION

3.1 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain plumbing equipment.

3.2 WATER HEATER INSTALLATION

A. Install new and relocated water heaters in accordance with manufacturer's instructions.

B. Following manufacturer’s instructions for piping the (2) water heaters in parallel and provide all required fittings, accessories, components, etc. to allow for a fully functional system.

3.3 THERMAL MIXING VALVE INSTALLATION

A. Install thermal mixing valve in accordance with manufacturer's instructions.

A. Equipment Mounting: Install thermal mixing valve on 2” uni-strut.

1. Maintain manufacturer's recommended clearances.
2. Arrange units so controls and devices that require servicing are accessible.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Install thermal mixing valve and fittings furnished by equipment manufacturer but not specified to be factory installed.

3.4 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturers written instructions.

END OF SECTION

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SECTION 22 40 00
PLUMBING FIXTURES

1. GENERAL

1.1 SECTION INCLUDES

A. Installation requirements of plumbing fixtures scheduled in Plumbing Fixture Schedule.

B. Plumbing fixture carriers.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING GUIDELINES

A. References

B. Submittals

C. Quality Assurance

D. Delivery, Storage and Handling

1.3 FIELD MEASUREMENTS

A. Verify that field measurements are as indicated on shop drawings and instructed by the manufacturer.

B. Confirm that millwork is constructed with adequate provision for the installation of countertop lavatories and sinks.

2. PRODUCTS

2.1 PLUMBING FIXTURES

A. Refer to Plumbing Fixture, Accessory, and Connection Schedule on drawings for all required product information.

1. Water closets shall be vitreous china construction, wall mounted, 1.6 gallon flush, white with white seats unless scheduled otherwise.

a. Acceptable manufacturer for water closets are Kohler, Sloan, Zurn and American Standard.

b. Flush valves shall be sensor-operated, hardwired, with 1” connection. Acceptable manufacturers are Zurn, Slan and AMTC.

2. Lavatories

a. Faucets shall be sensor operated, battery powered, and serviceable from above the sink. Acceptable manufacturers are Zurn and Sloan.
b. Sink: Elkay Stainless Steel 22" x 19" x 5-1/2" Wall Hung Lavatory Sink or approved equal. Sink is manufactured from 18 gauge 304 Stainless Steel with a Buffed Satin finish, Rear Center drain placement, and Bottom only pads.

3. Laboratory sinks

a. See Plumbing Fixture, Accessory, and Connection Schedule.

4. Scullery sinks

a. See Plumbing Fixture, Accessory, and Connection Schedule.
b. Sink: Just Mfg or equivalent stainless steel 96" x 27-1/2" x 14" Floor Mount Double Scullery Sink w/L&R Drainboards Coved Corners. Sink shall be manufactured from 14 gauge 304 Stainless Steel with a Buffed Satin finish, Center drain placement.
c. Faucet: Just Mfg m/n JPR-309 or equivalent.

1) Exposed wall or backsplash mount on 8 inch centers
2) 44" stainless steel hose with rubber interior
3) Brass mixing faucet has 1/2" flanged union inlets
4) Integral ball checks in faucet prevents water cross flow
5) Handles are fully open in less than 1/2 turn
6) Wall bracket assembly for secure installation included
7) Flowrate: 1.6 GPM
8) Compliant with:

a) NSF/ANSI 61/9- Annex G
b) AB1953
c) ANSI A112.18.1 / CSA B125.1

9) Finish: Polished chromeplate

5. Mop sinks

a. See Plumbing Fixture, Accessory, and Connection Schedule.
b. Manufactured by Stern-Williams Co., Inc.or equivalent. Shoulders shall not be less than 9-3/4" high inside measurement, and not less than 1-1/4" wide. Tiling flange, cast integral, shall extend 1" above shoulder on 1,2 or 3 sides (as job required).

Drain shall be cast brass with stainless steel strainer cast integral and shall provide for a caulked lead connection not less than 1" deep to a 3" pipe. Receptor composed of pearl grey marble chips and white Portland cement ground smooth, grouted and sealed to resist stains. Stainless steel cap of one piece 20 ga. 302 stainless steel cast integral on all four sides.

6. Showers

a. See Plumbing Fixture, Accessory, and Connection Schedule.
b. Complete commercial shower system includes: an R120SS pressure balance valve and trim, a wall supply with 1/2" NPT female inlet and 1/2" NPSM male outlet, a 59" (1500mm) metal shower hose, vacuum breaker, a “Fixed” personal shower, and a 36" Slide Bar. Valve features a cast brass body, washerless 47mm ceramic disc valve cartridge with volume and temperature control and hot limit safety stop. Pressure balancing cartridge maintains constant output temperature in response to changes in relative hot and cold supply pressure. One-half inch direct sweat inlets and outlets. With screwdriver stops. Durable metal handle. Rough-in plaster guard designed for use as thin-wall mounting adaptor. Fixed hand shower with 2.5gpm/9.5L/min. flow restrictor. Slide bar features an adjustable shower holder which can be set at any height or position along the bar and angle up to 45˚.

2.2 PLUMBING FIXTURE CARRIERS

A. All wall mounted fixtures such as water closets, lavatories, etc. shall be installed with compatible carriers. All carriers shall be commercial or industrial grade and shall be suitable for the fixture served, space available and building construction. All carriers shall extend to the floor and be anchored into the slab.

B. Water closet carriers shall be heavy-duty type, rated for a minimum of 750 lbs.

3. EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.

B. Examine walls, floors, cabinets, and counters for suitable conditions where fixtures will be installed.

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

3.2 PREPARATION

A. Rough-in fixture piping connections in accordance with minimum sizes indicated in fixture rough-in schedule for particular fixtures.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install each fixture with trap with 2 slip joints, easily removable for servicing and cleaning.

C. Provide chrome plated rigid or flexible supplies to fixtures with stops, reducers, and escutcheons.

D. Install components level and plumb.

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

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

3.4 WATER CLOSET INSTALLATION

a. Water-Closet Installation:

1) Install level and plumb according to roughing-in drawings.

2) Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1. Coordinate exact locations with drawings.
3) Where installing piping adjacent to water closets, allow space for service and maintenance.

b. Support Installation:

1) Use carrier supports with waste-fitting assembly and seal.
2) Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.

c. Flushometer-Valve Installation:

1) Install flushometer-valve, water-supply fitting on each supply to each water closet.
2) Attach supply piping to supports or substrate within pipe spaces behind fixtures.

3) Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
4) Install actuators in locations that are easy for people with disabilities to reach.

d. Install toilet seats on water closets.
e. Wall Flange and Escutcheon Installation:

1) Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
2) Install deep-pattern escutcheons if required to conceal protruding fittings.

f. Joint Sealing:

1) Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2) Match sealant color to water-closet color.

3.5 LAVATORY AND SINK INSTALLATION

A. Install lavatories and sinks level and plumb according to roughing-in drawings.

a. Install supports, affixed to building substrate, for wall-mounted lavatories and sinks.

b. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, according to ICC/ANSI A117.1. Coordinate exact locations with drawings.
c. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings.
d. Seal joints between lavatories/sinks, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color.

e. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories and sinks.
f. Install water-supply piping with stop on each supply to each faucet.

1) Exception: Use ball, gate, or globe valves if supply stops are not specified with lavatory/sink.
2) Install stops in locations where they can be easily reached for operation.

3.6 INTERFACE WITH OTHER PRODUCTS

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

3.7 ADJUSTING

A. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.

B. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.

C. Adjust water pressure at flushometer valves to produce proper flow.

D. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.8 CLEANING

A. Directly prior to project turnover, clean plumbing fixtures and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed water closets, urinals, and fittings.

C. Do not allow use of plumbing fixtures for use during construction unless approved in writing by Owner.

END OF SECTION

SECTION 22 67 00
REVERSE OSMOSIS (RO) WATER PIPING

1. GENERAL

1.1 SECTION INCLUDES

A. Pipe and pipe fittings.

B. Valves.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

A. Quality assurance.

B. References.

C. Submittals.

D. Operation and maintenance manuals.

1. Include functional data, operational procedures, maintenance procedures, and servicing instruction, and other information required in Section 22 05 00 for Maintenance Manuals.
2. Completed pipe pressure test report.

E. Project record documents.

1. Record actual locations of valves.

F. Delivery, storage, and handling.

1.3 REGULATORY REQUIREMENTS

A. Perform Work in accordance with International Plumbing Code and all manufacturer recommendations.

2. PRODUCTS

2.1 REVERSE OSMOSIS (RO) WATER PIPING, ABOVE GRADE

A. At contractor's option, one of the following systems shall be installed:

1. Polypropylene Piping System: Pipe manufactured to ASTM D1785 for dimensions and tolerances. Material shall be natural virgin copolymer polypropylene with no added plasticizers, pigments, or re-grind that meets the requirements of ASTM D4101 and is compliant with FDA 21.CFR 177.1520 Sections A1, B and C. Pipe shall be packaged in polybags at the point of manufacturing to preserve cleanliness.

   a. Fittings: Fitting material shall be of same type as pipe material. Fittings shall be designed for socket fusion utilizing manufacturer's recommended fusion tools and shall have a design working pressure of 150 psig at 68°F. Fittings shall be packaged in polybags at the point of manufacturing to preserve cleanliness.
   b. Joints: Socket fusion joints. Note that mechanical joints are not allowed.
   c. Joining Method: Electric coil fusion (electrofusion) or heat plate socket fusion. Note that if electrofusion is not used, the controller/heater shall be a bench machine with integral provisions for ensuring proper alignment and joint depth. Hand-held controller/heaters are not acceptable.
   d. Valves: Material shall be natural virgin copolymer polypropylene with no added plasticizers, pigments, or re-grind that meets the requirements of ASTM D4101 and is compliant with FDA 21.CFR 177.1520 Sections A1, B and C. Valves shall be designed for socket fusion utilizing manufacturer's recommended fusion tools and shall have a design working pressure of 150 psig at 68°F.

      1) Ball valves shall have two-way blocking capability, blow-out proof stem with double seals, FPM O-rings, PTFE valve seats, and elastomeric backing. Ball shall be full bore type. Valves shall be packaged in polybags at the point of manufacturing to preserve cleanliness.
      2) Diaphragm Valves: Diaphragm valves shall be constructed of PP with EPDM seal configurations, manufactured for installation in manufacturer's system. Valves shall be packaged in polybags at the point of manufacturing to preserve cleanliness.
      3) Check Valves: Check Valves shall be constructed of PVDF available in EPDM seal configurations manufactured for installation in manufacturer's system. Valves shall be packaged in polybags at the point of manufacturing to preserve cleanliness.

   e. Manufacturers: Subject to compliance with all specified requirements, provide products by:

      1) PPro-Seal by George Fischer Sloane.
      2) Enpure by IPEX.
      3) Approved equivalent.

2. PVC Low Extractable High Purity Piping System

a. General: UPW process piping and fittings shall be manufactured from a specialty low-extractable, Polyvinyl Chloride (PVC) compound with a Cell Classification of 12343 per ASTM D1784. All pipe and fittings shall be produced to Schedule 80 dimensions, manufactured in strict compliance to ASTM D1785 (pipe), and ASTM D2467 (fittings). These products shall carry a Type II pressure rating and consistently meet or exceed the applicable Quality Assurance test requirements of these standards with regard to dimensions, workmanship, burst pressure, flattening resistance and end-product quality. All UPW process valves shall be True Union-style diaphragm or True Union-style quarter-turn ball valves produced from the same low-extractable PVC compound. All valve diaphragms and seats shall be PTFE; valve O-rings shall be EPDM or FKM as applicable. All valve union nuts shall have buttress-style threads. All valve components shall be replaceable. System components shall be joined utilizing Spears® One-Step specialty solvent cement specifically formulated for joining the system that meet or exceed the requirements of ASTM D2564. All system components shall be manufactured in the USA by an ISO-certified manufacturer. All UPW piping and fittings shall be bagged and sealed immediately after manufacture to maintain cleanliness, and boxed and stored indoors at the manufacturing facility until shipped from the factory. UPW process pipe, fittings, valves and cement shall be that as manufactured by Spears® Manufacturing Company.

1) Fitting Product Description: UPW process fittings shall be manufactured from a specialty low-extractable, Polyvinyl Chloride (PVC) compound with a Cell Classification of 12343 per ASTM D1784. All fittings shall be produced to Schedule 80 dimensions, manufactured in strict compliance to ASTM D2467. All fittings shall be bagged and sealed immediately after manufacture to maintain cleanliness, and boxed and stored indoors at the manufacturing facility until shipped from the factory.
2) Pipe Product Description: UPW process piping shall be manufactured from a specialty low-extractable, Polyvinyl Chloride (PVC) compound with a Cell Classification of 12343 per ASTM D1784. All pipe shall be produced to Schedule 80 dimensions, manufactured in strict compliance to ASTM D1785. All piping shall be bagged and sealed immediately after manufacture to maintain cleanliness, and boxed and stored indoors at the manufacturing facility until shipped from the factory.
3) Valve Product Description: All UPW process valves shall be True Union-style diaphragm or True Union-style quarter-turn ball valves produced from a specialty low-extractable, Polyvinyl Chloride (PVC) compound with a Cell Classification of 12343 per ASTM D1784. All valve diaphragms and seats shall be PTFE; valve O-rings shall be EPDM or FKM as applicable. All valve union nuts shall have buttress-style threads. All valve components shall be replaceable. All Valves shall be bagged and sealed immediately after manufacture to maintain cleanliness, and boxed and stored indoors at the manufacturing facility until shipped from the factory.
4) Pipe, Fittings, and Valves: Pipe, fitting and valve material shall meet or exceed the requirements of ASTM D1784.

5) Solvent Cement: System components shall be joined utilizing Low Extractable One-Step specialty solvent cement specifically formulated for joining the system that meet or exceed the requirements of ASTM D2564. The standard practice for safe handling of solvent cements shall be in accordance with ASTM F402. Solvent cement shall be NSFcertified for potable water.

6) Manufacturer: The system fittings, piping and valves shall be manufactured from a specialty low extractable PVC compound and supplied by Spears® Manufacturing Company.

B. Piping to be installed upstream/downstream of UV filter (See 3. EXECUTION paragraph):

1. Stainless Steel Pipe: Schedule 10, ASTM A312/A312 M, Grade TP316L, seamless pipe.

a. Fittings: ASTM A 403/A 403M, Class S, seamless fittings matching pipe thickness and grade.
b. Joints: Welded.

C. Supports: All pipe supports shall use the pipe manufacturer's recommended support system. Support spacing shall be in accordance with the manufacturer's written instructions and recommendations.

D. In return air plenum applications, polypropylene RO Water piping must be fully insulated with 3M Fire Barrier Plenum Wrap 5A or equivalent fire wrap system. All damage to fire wrap system must be repaired in accordance with manufacturer recommendations to provide a completely protected system.

3. EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Route piping in orderly manner and install level and plumb.

C. Install piping to conserve building space and not interfere with use of space.

D. Install hangers spaced as recommended by manufacturer, but free from sags or bends in system.

E. Install padded hangers and support rods spaced as recommended by manufacturer, but in no case less than:

1. NPS 1 and Smaller: 32 inches with 3/8-inch rod.
2. NPS 1-1/4 to NPS 2: 48 inches with 3/8-inch rod.
3. NPS 2-1/2 and NPS 3: 48 inches with 1/2-inch rod.

F. Install padded supports for vertical piping NPS 2-1/2 and larger every 120 inches and midstory for NPS 2 and smaller.

G. Group piping whenever practical at common elevations.

H. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

I. RO piping installation shall only be performed by factory trained and certified installers in accordance with the manufacturer's written procedures. Each installer shall complete the manufacturer's certification course, including written test examinations and submittal of test fusion welds to the factory for evaluation and file. Installation practices, including support spacing and expansion considerations, shall be in accordance with the manufacturer's certification course and written recommendations.

1. The manufacturer shall also provide training and certification for Owner's personnel at a time separate from the contractor training. Coordinate exact time with Owner.
2. Installer shall adhere to all manufacturer requirements for preheating and fusion times in cold weather.
3. Fuse seal piping: Upon completion of the project, the contractor shall send electrofusion controller/heater (used on polypropylene pipe) back to factory for calibration and necessary repairs prior to delivering to the Owner. Contractor shall be responsible for any expense accrued due to the recertification and repair of the electrofusion controller/heater. Contractor shall also provide all associated components required to maintain the piping system.

J. Provide clearance for access to valves and fittings.

K. Provide access where valves and fittings are not exposed.

L. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

M. Install valves with stems upright or horizontal, not inverted.

N. Use of FPT Polypropylene fittings shall be kept to a minimum. When used, FTP fittings shall be reinforced with a stainless steel hose clamp once threaded together.

O. Install stainless steel pipe and fittings upstream and downstream of RO Water system ultraviolet sterilizer to protect RO water piping from excess sterilizer light. Transition to specified RO water

pipe and fittings for remainder of system. See drawings for further information.

3.2 APPLICATION

A. Install polypropylene and PVC flanges with backing rings downstream of valves and at equipment or apparatus connections. As an alternative, valves can be used as unions if valve is specifically designed with union ends.

B. Flanged joints, where required, shall be installed per piping manufacturers' recommendations using full-face, 1/8-inch thick, EPDM flange gasket. Install and torque stainless steel bolts per piping manufacturers' recommendations.

C. Install ball or diaphragm valves for shut-off and to isolate equipment, part of systems, or vertical risers.

D. Install ball or diaphragm valves for throttling, bypass, or manual flow control services.

E. Provide spring loaded check valves on discharge of water pumps.

3.3 PIPING SYSTEM PRESSURE TESTING

A. Submit copy of Pipe Pressure Test Log provided in section 22 05 00 for each section of piping tested.

B. System to be hydrostatic tested using RO water at one and a half times the intended working pressure of the system, not to exceed the maximum working pressure of any single component in the system. All air must be evacuated from the piping system at high points and pressure brought up slowly as to not create hydraulic shock. Inform Owner's Representative a minimum of 2 weeks in advance of pressure test. Note that the use of air or other compressed gases will not be allowed for pressure testing of RO Water piping.

C. Leave uncovered and unconcealed all new, altered, extended, or replaced piping until it has been tested and approved. Expose all such work for testing that has been covered or concealed before it has been tested and approved.

3.4 PIPE SYSTEM CLEANING

System cleaning shall be completed by the Water Purification System equipment manufacturer. See Section 22 67 01.

END OF SECTION

SECTION 22 67 01
WATER PURIFICATION SYSTEM EQUIPMENT

1. GENERAL

1.1 SECTION INCLUDES

A. Water purification system equipment.

1.2 RELATED SECTIONS

A. Section 22 67 00 – Reverse Osmosis Water Piping.

1.3 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

A. References

B. Submittals

C. Operation and maintenance manuals.

1. Include functional data, operational procedures, maintenance procedures, and servicing instruction, and other information required in Section 22 05 00 for Maintenance Manuals.
2. Include warranty information as specified within this section.
3. Include inspection report completed by factory-authorized service representative.
4. Include certified sampling test reports for required water performance characteristics.

1.4 QUALITY ASSURANCE

A. See Section 22 05 00.

B. Perform Work in accordance with State and Local standards.

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

1.5 WARRANTY

A. Provide written three-year warranty from the date of Substantial Completion for repair or replacement of pure water equipment components that fail in materials or workmanship.

2. PRODUCTS

2.1 Refer to Water Purification Equipment Schedule on Drawings for performance requirements.

2.2 All water purification system equipment components shall be provided as part of a package by a single manufacturer. Subject to compliance with the specified requirements, manufacturers offering products that may be incorporated into the package include, but are not limited to:

A. Culligan (Basis of Design)

B. Siemens.

C. Millipore.

D. US Filter.

E. Or approved equivalent.

2.3 All required system components required to produce the quality and quantity of water listed in the equipment schedule on the drawings shall be provided by the pure water system equipment manufacturer. There shall be no requirement for the Owner to lease any items, such as deionization tanks, carbon filter tanks, etc.

3. EXECUTION

3.1 WATER PURIFICATION SYSTEM EQUIPMENT INSTALLATION

A. Engage a manufacturer-authorized installer to install all water purification equipment and interconnecting piping.

B. Install all components in accordance with manufacturer's instructions.

C. Anchor tanks and floor-mounted equipment to substrate.

D. Pipe relief valves and drains to nearest floor drain.

E. All piping upstream of reverse osmosis unit shall be considered domestic soft cold water. Install per Section 22 10 00.

F. All piping downstream of reverse osmosis shall be considered RO water and shall be install per Section 22 67 00.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Services:

1. Engage a factory-authorized service representative to inspect field assembly of components and electrical connections. Report results in writing.

B. Testing:

1. After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist. See Section 22 67 00 for testing requirements.
2. After water purification system equipment and interconnecting piping has been leak-tested, the water purification system equipment supplier shall clean the system loop piping, components, and storage tank by circulating a solution of chlorine dioxide and water, in concentration recommended by manufacturer, for a minimum of 2 hours. During circulation, all valves and faucets shall be opened at some point as necessary to clean all portions of the system. Then, rinse with reverse osmosis system purified water and test for chlorine dioxide level to ensure no residue remains. If residue remains, repeat rinse and retest cycle until all components and piping are free of residue.
3. After electrical connections have been energized, start system and confirm proper operation of all components. Remove malfunctioning units, replace with new units, and retest.
4. Replace damaged or malfunctioning controls and equipment.

C. Sampling:

1. Sample effluent after startup and at three consecutive seven-day intervals (total of four samples), and prepare certified test reports for required water performance characteristics.

D. Contractor Coordination

1. The manufacturer and contractor shall coordinate all work to ensure a fully functional and leak-free system. Permanent labeling shall be provided at the demarcation point between the water piping (domestic soft cold water piping and RO water piping) installed by the Contractor and the water purification system equipment/piping installed by the manufacturer to indicate the responsible party (manufacturer or contractor) for all portions of work in the event of future leaks outside of the warranty period.
2. All water purification system equipment components shall be properly labeled with serial numbers, part numbers, and contact information.

3.3 COMMISSIONING

A. Engage a factory-authorized service representative for a minimum of 16 hours to supervise construction and to perform startup service.

END OF SECTION

SECTION 23 05 00
BASIC HVAC REQUIREMENTS

1. GENERAL

1.1 SECTION INCLUDES

A. This section describes Basic Mechanical Requirements to provide for a complete installation of all mechanical systems for this project. This section shall apply to all other Division 23 specification sections as well as all work shown on the drawings.

B. It is the intent of the Mechanical Division of the Specifications that all mechanical work specified herein be coordinated as required with the work of all other Divisions of the Specifications and Drawings so that all installations operate as designed.

C. All systems shall be completely assembled, tested, adjusted and demonstrated to be ready for operation to the satisfaction of the Owner's representative.

D. The Contractor shall note that, in some cases, piping as shown on the Drawings provide general location and routing information only. The Contractor shall be responsible for providing interference-free systems with proper clearance to facilities and equipment.

E. Where the word "provide" is used, it shall mean "furnish and install" unless otherwise noted or specified.

F. Note that the words "mechanical" and "plumbing" are used interchangeably throughout the Division 22 and 23 specification sections.

1.2 RELATED SECTIONS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this section and all other sections of Division 23.

1.3 DESCRIPTION OF WORK

A. The work included under this section consists of providing all labor, materials, supervision, and construction procedures necessary for the installation of the complete mechanical systems required by these specifications and/or shown on the drawings of the contract.

B. The Contract Drawings are shown in part diagrammatic intended to convey the scope of work, indicating the intended general arrangement of equipment, piping fixtures, etc. The Contractor shall follow the drawings in laying out work and verify clearances for the installation of the materials and equipment based on the dimensions of actual equipment furnished. Whenever a question exists as to the exact intended location of outlets or equipment, obtain instructions from the Architect/Engineer before proceeding with the work.

1.4 QUESTIONS OF INTERPRETATION

A. If questions arise during the bidding process regarding the meaning of any portion of the contract documents, the prospective bidder shall submit the questions to the Architect/Engineer for clarification. Any definitive interpretation or clarification of the contract documents will be published by addenda, properly issued to each person holding documents, prior to the bid date. Verbal interpretation or explanation not issued in the form of an addendum shall not be considered part of the bidding documents. When submitting questions for clarification, adequate time for issuance and delivery of addenda must be allowed.

B. The Architect/Engineer shall be the sole judge regarding interpretations of conflicts within contract documents.

1.5 CONTRACT DOCUMENT DISCREPANCIES

A. If any ambiguities should appear in the contract documents, the Contractor shall request clarification from the Architect/Engineer before proceeding with the work. If the Contractor fails to make such request, no excuse will thereafter be entertained for failure to carry out the work in a manner satisfactory to the Architect/Engineer. Should a conflict occur within the contract documents, the Contractor is deemed to have estimated the more expensive way of doing the work unless a written clarification from the Architect/Engineer was requested and obtained before submission of bid.

B. The Contractor acknowledges and understands that the Contract Documents are a two-dimensional representation of three-dimensional objects. This representation may include imperfect data, interpreted codes, utility guidelines, three-dimensional conflicts, and required field coordination items. Such deficiencies should be 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.

C. The Contractor shall follow the drawings in laying out work and verify clearances for the installation of the materials and equipment based on the dimensions of actual equipment furnished. Whenever a question exists as to the exact intended location of materials or equipment, obtain instructions from the Architect/Engineer before proceeding with the work.

D. If there is a conflict between manufacturer's recommendations and the Contract Documents, the manufacturer's recommendations shall govern with no additional cost to the Owner.

1.6 PERMITS

A. All permits, fees, licenses, etc. required for this project shall be obtained by the Contractor.

1.7 QUALITY ASSURANCE

A. Installers shall have at least 2 years of successful installation experience on projects with mechanical installation work similar to that required by the project. All equipment and materials shall be installed in a neat and workmanlike manner and shall be aligned, leveled, and adjusted for satisfactory operation, unless noted otherwise in other mechanical sections.

B. Manufacturer of equipment and materials must be regularly engaged in the manufacture of the specified equipment and material with similar construction and capacities and whose products have been in satisfactory use in similar service for not less than five (5) years, unless noted otherwise in other Mechanical Sections.

C. Qualify welding processes and operators for structural steel according to AWS D1.1. "Structural Welding Code - Steel.

D. Quality welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."

E. Comply with provisions of ASME B31 Series "Code for Pressure Piping", including all addenda.

F. Contractor signed welder certificate(s) shall be submitted. Certify that each welder has passed AWS qualification tests for the welding processes involved and that certification is current. A record shall be maintained on the job site showing the date and results of qualification tests for each welder employed on the job. One certified copy of the qualification test for each welder so employed shall be furnished to the Owner's representative.

G. For all the refrigerant work/service required by this project, all refrigerant technicians shall be EPA/ASHRAE 34 certified for corresponding classification type I, II, III and/or IV.

1.8 REFERENCES

A. The design, manufacture, testing, and method of installation of all equipment and materials furnished under the requirements of this specification shall conform to the following as applicable:

1. Safety and Health Regulations for Construction.

2. Occupational Safety and Health Standards, National Consensus Standards and Established Federal Standards.
3. ABMA - American Boiler Manufacturers Association.
4. ACCA - Air Conditioning Contractors of America.
5. ACGIH - American Conference of Governmental Industrial Hygienists.
6. ADC - Air Diffusion Council.
7. AGA - American Gas Association.
8. AIHA - American Industrial Hygiene Association.
9. AMCA - Air Movement and Control Association.
10. ANSI - American National Standards Institute.
11. ARI - Air-Conditioning and Refrigeration Institute.
12. ASA - Acoustical Society of American.
13. ASHRAE - American Society of Heating, Refrigerating, and Air-Conditioning Engineers.
14. ASME - The American Society of Mechanical Engineers.
15. ASTM - American Society of Testing and Materials.
16. CAGI - Compressed Air and Gas Institute.
17. CTI - Cooling Tower Institute.
18. EJMA - Expansion Joint Manufacturers Association.
19. ETL - Engineering Tests Laboratory.
20. HEI - Heat Exchange Institute.
21. HI - Hydraulic Institute.
22. HYD I - Hydronics Institute.
23. ICBO - International Conference of Building Officials.
24. ICC – International Code Council.
25. NEBB - National Environmental Balancing Bureau.
26. NEC - National Electrical Code.
27. NEMA - National Electrical Manufacturers Association.
28. NFPA - National Fire Protection Association.
29. NSF - National Sanitation Foundation.
30. SAE - Society of Automatic Engineers.
31. SMACNA - Sheet Metal and Air Conditioning Contractors' National Association.
32. TEMA - Tubular Exchanger Manufacturers Association.
33. UL - Underwriters Laboratories, Inc.
34. International Plumbing Code.
35. International Mechanical Code.
36. Other governing, state, and local codes that apply.

1.9 SUBMITTALS

A. General: Follow the procedures specified in Division 1 Sections "General Conditions" and “Special Conditions”.

B. Shop drawings shall include the minimum following information as applies. Additional specific information required is outlined in other Mechanical Sections.

1. Certified performance and data with system operating conditions indicated (winter and summer performance as necessary). All coil, fan, and pump performance data shall be computer generated.

    a. Submit sound power level data for all inlets, outlets, and casing radiation at rated capacities for all air handling equipment. Provide calculated sound power data based on AMCA 320 sound intensity test methods.
    b. Where filters are included with equipment, provide data of filter media, filter performance data, filter assembly, and filter frames.

2. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicating, weights (shipping, installed, and operating), furnished specialties and accessories; and installation and start-up instructions.
3. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loading, required clearances, gages and finishes of materials, and methods of assembly of components.
4. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to electrical equipment. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring required for final installation of electrical equipment and controls. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
5. Maintenance Data: Submit maintenance data and parts list for each mechanical equipment, control and accessory; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual; in accordance with requirements of Division 1.

C. Provide separate shop drawing submittals for all items listed in Shop Drawing and Submittal Log in Division 1.

D. Coordination drawings

1. Drawings:

a. Provide coordination in determining adequate clearance and space requirements for fire suppression equipment, mechanical equipment, electrical equipment, and other items/equipment in the project. The Architect/Engineer reserves the right to determine space priority of equipment in the event of interference between pieces of equipment, piping, conduit, ducts and equipment of the trades. The Architect/Engineer will only review conflicts and give an opinion but will not perform as a coordinator.

b. Provide coordination drawings indicating structural components, reflected ceiling layout, fire suppression items, mechanical items, electrical items, and other systems. Indicate on the coordination drawings where components will be installed and how the service access area to such items shall be maintained. Illustrate items requiring access for maintenance or adjustment.

c. The Contractor will not be allowed any time extensions for participation in the coordination drawing process. The Contractor will not be allowed any contract cost extra for any additional fittings, rerouting or changes of duct size to equivalent sizes to those shown on the drawings that may be determined necessary through the coordination drawing process.

d. Deviations from the contract documents that are necessary for overall system installation and coordination shall be brought to the attention of the Architect/Engineer. Such necessary changes in the contract scope discovered through the coordination drawing process will be covered by the requirements of the "change order" process.

e. Access panels shall occur only in gypsum wallboard or plaster ceilings where indicated on the drawings or as needed to provide access to equipment, dampers, or valves. Access to fire suppression and other items shall be through accessible acoustical ceiling areas. Additional access panels will not be allowed without written approval from the Architect/Engineer at the coordination drawing stage and only after alternatives are reviewed. Layout changes shall be made to avoid additional access panels. If additional access panels are required, they shall be provided at no additional cost to the Owner.

f. Soffit penetrations and light alcoves shall be fully coordinated with hanging devices, studs, fire/smoke ratings, and structural support requirements.

2. The Contractor and subcontractors responsible for items of work located in or above ceilings shall participate in the coordination drawing process. Participation is mandatory. If the Contractor or subcontractor fails to participate in the coordination drawing process, the Owner reserves the right to do the following:

a. Stop construction progress payments for work performed by the Contractor. Payments will be reinstated only after the Contractor or subcontractor resumes participation in the coordination drawing process.

b. Require the relocation and resizing of components as necessary to ensure components will be installed as intended. In the event the Contractor did not participate in the coordination process, the Contractor will not be entitled to contract cost increases or time extensions due to Owner-initiated changes in the work.

c. The Contractor shall be held responsible for unnecessary rework that is attributable to failure to participate in the coordination process.

3. Drawings shall be prepared at 1/4 inch = 1 foot, 0 inches (minimum).

a. Coordination participants shall provide equipment installation and clearance requirements. This information shall be indicated on the coordination drawings.

b. Coordination drawings shall indicate the following major system components (including insulation, hub or connection widths with verification of turning radius):

1) **Roof drain leaders**
2) **Large waste piping**
3) **Sprinkler mains**
4) **Equipment located above the ceiling**
5) **Heating hot water piping**
6) **Chilled water piping**
7) **Conduit runs 2 inches and larger**
8) **Cable tray**
9) **Bus duct**
10) **Recessed light fixtures**
11) **Building wiring or cable trays**
12) **Ceiling heights as shown in contract documents and thickness of system**
13) **Soffits (including framing of supports)**
14) **Access points and clearances required**
15) **Access panels**
16) **Valves**
17) **Dampers**
18) **Coils**
19) **Ductwork**
20) **Fire-rated wall, partition, and floor penetrations**
21) **Steam and condensate piping**
22) **Space allotted for future utilities**
23) **Equipment in mechanical and electrical spaces**

c. Information shall be delineated to indicate distances from column centerlines, pipe/equipment size, and distance from finished floor to bottom of pipe/equipment and hangers.

4. The coordination drawings shall be submitted to the Architect/Engineer and Owner's representative for review. The submitted coordination drawings shall indicate which contractors participated in the process and where conflicts appear to occur even after the priority ranking of utility routing has been utilized. In the event that conflicts require input from the Architect/Engineer, recommended solutions will be provided with the coordination drawings for review by the Architect/Engineer. The Architect/Engineer will review and return an opinion to the contractors for implementation. All contractors shall agree to the final coordinated layout by signing off on the coordination drawings before any construction can begin.

5. Maintain an updated set of coordination drawings at the job site reflecting changes, modifications and adjustments. Changes shall be reflected and sets or new sheets reissued to the Architect/Engineer and the Owner for review on a monthly basis with changes "clouded" and brought to the attention of the Architect/Engineer and the Owner.

6. **When a change order request is issued, the affected subcontractors shall review the coordination drawings and bring to the attention of the Contractor and the Architect/Engineer revisions necessary to the work of others not directly affected by the change order.**
7. **Contractors that fail to cooperate in the coordination drawing effort shall be responsible for all costs incurred for adjustments to the work made necessary to accommodate installations. Provide adequate clearance and access through accessible ceilings. Conflicts that result after the coordination drawings are signed off will be the responsibility of the Contractor or subcontractor who did not properly identify their work or installed the work improperly.**

1.10 SUBSTITUTES

A. Refer to the General Conditions and Special Conditions sections of this Specification for general substitution requirements and information.

B. Where the terms "or equivalent" is used, the Contractor may substitute alternate equipment, materials, etc. subject to review by the Architect/Engineer and the Owner's representative during the submittal phase of the project.

C. Where the term "or approved equivalent" is used, the Contractor may not substitute alternate equipment, materials, etc. unless requesting approval at least ten (10) days before the bid date. Notifications of any such approvals by the Architect/Engineer shall only be made in writing by Addendum.

D. Where the term "no equivalent" is used, the Contractor must provide the specified or scheduled equipment, materials, etc.

E. Final determination regarding substitutions shall be by the Architect/Engineer.

1.11 WARRANTY

A. Refer to the General Conditions section of this Specification for general warranty requirements and information. Additional warranty requirements are specified in subsequent Mechanical Sections.

1.12 CLOSE OUT AND OPERATION INSTRUCTIONS

A. Operate each system and item of equipment in a test run of appropriate duration, but no less than 7 days, to demonstrate sustained, satisfactory performance. Adjust and correct operations as required for proper performance.

B. Any system placed in temporary operation for testing or for the convenience of the Contractor during construction shall be properly maintained and operated by the Contractor.

C. All systems shall be protected against freezing, flooding, corrosion or other forms of damage prior to acceptance by the Owner.

D. Material or equipment damaged, shown to be defective or not in accordance with the Specifications shall be repaired or replaced to the satisfaction of the Owner's representative.

E. All tests shall be made after notification to and in the presence of the Owner's representative.

F. Before starting up any system, each piece of equipment comprising any part of the system shall be checked for proper lubrication and any other condition which may cause damage to the equipment or endanger personnel.

G. After systems have been demonstrated to be satisfactory for 7 consecutive days and ready for permanent operation, all permanent pipe line strainers shall be cleaned, valve and packings properly adjusted, lubrication checked and replenished if required. Temporary piping, etc. shall be removed and openings restored in a permanent manner acceptable to the Owner's representative.

H. Conduct a walk-through instruction seminar for the Owner's personnel pertaining to the continued operation and maintenance of mechanical equipment and systems. Explain the identification system, maintenance requirements, operational diagrams, temperature control provisions, sequencing requirements, security, safety, efficiency and similar features of the systems. Walk through must be documented as to those attending and subjects covered. Walk through document(s) shall be signed and dated by the contractor's representative and the owner's representative.

1. Provide instructional training as outlined in individual equipment specification sections.

I. At the time of substantial project completion, turn over the prime responsibility for operation of the mechanical equipment and systems to the Owner's operating personnel. Until the time of final acceptance, provide full time operating personnel, who are completely familiar with the work, to consult with and continue training the Owner's personnel.

1. If any systems are operated prior to substantial completion, the contractor shall perform all necessary preventative maintenance according to all manufacturer recommendations.

1.13 RECORD DOCUMENTS

A. Prepare as-built documents in accordance with the requirements in Division 1 Section "PROJECT CLOSEOUT." In addition to the requirements specified in above, indicate the following installed conditions:

1. The Mechanical Contractor shall provide the Owner with as-built drawings for ductwork mains and branches, size and location, for both exterior and interior; locations of dampers and other control devices; filters, boxes, and terminal units and indicate all devices requiring periodic maintenance or repair, such as control power transformers, LACS panels/routers, field controllers, duct static pressure sensors, piping pressure sensors, etc.
2. All mechanical systems as described in the Specifications and/or shown on the drawings.
3. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.). Valve location diagrams, complete with valve tag chart. Refer to Division 23 Section "Mechanical Identification." Indicate actual inverts and horizontal locations of underground piping.
4. Equipment/material locations (exposed and concealed), dimensioned from prominent building lines.
5. All items must be dimensioned in horizontal and vertical plans to allow Architect/Engineer to update Building Information Model (BIM) file for Owner.

1.14 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1 Section "PROJECT CLOSEOUT." In addition to the requirements specified in Division 1, include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. Servicing instructions and lubrication charts and schedules.

B. Provide electronic copies, preferably in Adobe Acrobat Portable Document Format (pdf), of all maintenance manuals to Temperature Control Contractor for use in EMCS front-end system. Provide data in file types compatible with EMCS.

2. PRODUCTS (NOT APPLICABLE).

3. EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

B. Store and handle material and equipment in compliance with manufacturers' recommendations to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

C. Use proper lifting equipment where size/weight requires handling by such means.

D. Comply with manufacturer's rigging and moving instructions for unloading material and equipment, and moving them to final location.

E. Equipment requiring disassembly for access purposes shall be disassembled and reassembled as required for movement into the final location following manufacturer's written instructions.

F. Deliver material and equipment as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

G. Mechanical Contractor shall schedule deliveries so as to minimize space and time requirements for storage of materials and equipment on site.

3.2 ROUGH-IN

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

B. Refer to equipment specifications in Divisions 2 through 26 for rough-in requirements.

3.3 COORDINATION

A. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.

B. Coordinate the mechanical work with work of the different trades so that:

1. Interferences between mechanical, electrical, architectural, and structural work, including existing services, will be avoided.
2. Within the limits indicated on the drawings, the maximum practicable space for operation, maintenance repair, removal and testing of mechanical and other equipment will be provided.
3. Pipes, ducts, and similar items, shall be kept as close as possible to ceiling, walls, and columns, to take up a minimum amount of space. Pipes, ducts, and similar items shall be located so that they will not interfere with the intended use of other equipment.

C. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components as they are constructed.

D. Furnish and install, without additional expense to the Owner, all offsets, fittings and similar items necessary in order to accomplish the requirements of coordination.

3.4 MECHANICAL INSTALLATIONS

A. All dimensions and clearances affecting the installation of work shall be verified in the field in relation to established datum, to building openings and to the work of other trades.

B. The location of all equipment and systems shall be coordinated to preclude interferences with other construction.

C. Should interferences occur which will necessitate deviations from layout or dimensions shown on the Drawings, the Architect/Engineer and the Owner's representative shall be notified and any changes approved before proceeding with the work.

D. Arrange for chases, slots, and openings in other building components during progress of construction to allow for mechanical installations.

E. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum possible headroom.

F. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

G. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect/Engineer.

H. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

I. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.

J. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

K. Welding, sweating, or brazing operations

1. All cutting, welding, brazing, or sweating operations carried on in the vicinity of, or accessible to, combustible material shall be adequately protected to make certain that a spark or hot slag does not reach the combustible material and start a fire.
2. When it is necessary to do cutting, welding, brazing, or sweating close to wood construction, in pipe shafts, or other locations where combustible materials can not be removed or adequately protected, employ fireproof blankets and proper fire extinguishers. Position another individual nearby to guard against sparks and fire.
3. Whenever combustible material has been exposed to molten metal or hot slag from welding or cutting operations, or spatter from electric arc operations, a guard shall be kept at the place of work for at least one hour after completion to verify that smoldering fires have not been started.
4. Whenever welding or cutting operations are carried on in a vertical shaft or where floor openings exist, a fire guard shall be employed to examine all floors below the point of the welding or cutting operation. The fire guard shall be kept on duty for at least one hour after completion to verify that smoldering fires have not been started.
5. Before any work involving cutting, welding, brazing, or sweating operations is started, consult with the Architect/Engineer as to particular safety precautions to be employed on the work.

3.5 ACCESSIBILITY

A. All work shall be installed so as to be accessible for operation, maintenance and repair with particular attention given to locating valves, controls and equipment requiring periodic lubrication, cleaning, adjusting or servicing of any kind.

3.6 LUBRICATION AND TOOLS

A. Provide a fresh charge of lubricant in accordance with manufacturer's recommendations to all equipment requiring lubrication prior to start-up and maintain lubrication as required until acceptance by Owner.

B. Provide for each piece of equipment any special tools and a list of such tools required for the operation or adjustment of the equipment and turn over to the Owner's representative prior to final acceptance of the equipment.

3.7 START-UP

3.8 PIPING SYSTEMS PRESSURE TESTING

A. The following personnel in the order listed shall be considered acceptable witnesses of all piping pressure testing:

1. Local Authority Having Jurisdiction
2. Owner's Representative
3. Mechanical Engineer / Architect
4. General Contractor's Foreman

B. Removal of pressure charge and associated drain down shall also be witnessed.

C. Mechanical contractor shall provide a minimum of 24-hour notice to at least one of the above listed parties before commencing any piping systems pressure test.

D. Pressure gauge requirements: Provide recently calibrated gauge with 4" face and a range such that test pressure is between 50% and 100% of gauge range. For example, a gauge with a 15 psig range is acceptable for a 10 psig pressure test, whereas a gauge with a 30 psig range is unacceptable in this application. Gauge resolution shall be suitable for type of testing, system size and test media. Gauge shall have been recently calibrated.

E. All piping pressurizing equipment (i.e., air compressor) shall be disconnected before test is commenced and shall remain disconnected for the entire duration of the test.

F. Entire system shall be properly vented before test is commenced.

G. For specific piping pressure testing requirements and procedures, see applicable piping systems specification sections.

H. Submit completed "Pipe Pressure Test Log" provided at the end of this Section for each pressure test before final project closeout. Test log shall also be included in operation and maintenance manuals.

NOTE: USE MULTIPLE FORMS IF NECESSARY

3.9 GENERAL CONTRACTOR - MECHANICAL EXTENT OF WORK

A. Access Panels

1. Furnish and install panels for access to valves and dampers and similar items where no other means of access, such as readily removable, sectional ceiling is shown or specified.

2. The plans indicate the location of all anticipated access panels. The Division 23 Contractor shall make every effort to locate all material and equipment requiring service and maintenance above accessible ceilings or utilize the indicated access panels. Material and equipment requiring service and maintenance that is shown above inaccessible ceilings shall be relocated to accessible or exposed areas whenever possible. When these items are located in exposed areas, the Division 23 Contractor is to verify with the Architect/Engineer that the installation will not affect the aesthetics of the building. However, when it is not possible to locate these items in accessible or exposed areas due to the configuration of the actual installation of the mechanical and other trade systems or aesthetic reasons, additional access panels shall be provided. The contractor shall be equitably compensated for the additional access panels.
3. Refer to Section 08 31 13 – Access Doors and Panels for specific information on type and size of panels

B. Cutting and Patching

1. General: Perform cutting and patching in accordance with Division 1 Section "CUTTING AND PATCHING." In addition to the requirements specified in Division 1, the following requirements apply:

2. The Division 23 Contractor shall coordinate all cutting and patching of holes, in existing building and new construction which are required for the passage of mechanical work.
3. Division 23 Contractor is to notify the General Contractor prior to submitting his bid, the number, size and location of all cutting and patching requirements. The Division 23 Contractor shall be liable for all associated costs of cutting and patching for mechanical work upon failure to notify the General Contractor prior to bid submission.
4. Under no circumstances shall any structural members, load-bearing walls or footings be cut without first obtaining written permission from the Engineer.
5. Cut, channel, chase and core drill floors, walls, partitions, ceilings, and other surfaces necessary for mechanical installations. Perform cutting by skilled mechanics of the trades involved.
6. Patching of concrete openings shall be filled with grout and finished smooth with the adjacent surface.
7. All below-grade openings for pipe shall be sealed with interlocking synthetic rubber line assembly, Link-Seal by Thunderline Corporation or equal.
8. **All penetrations through the walls, floor, or structure of laboratory spaces, laboratory support spaces, lecture halls, classrooms, conference rooms, corridors or other areas in which relative pressurization relationships are important shall be sealed airtight. Refer to the drawings for additional information regarding rooms in which maintaining pressurization is important.**
9. Repair cut surfaces to match adjacent surfaces.
10. Perform cutting, fitting, and patching of mechanical equipment and materials required to:

    a. Uncover work to provide for installation of ill-timed work.
    b. Remove and replace defective work.

c. Remove and replace work not conforming to requirements of the Contract Documents.
d. Remove samples of installed Work as specified for testing.
e. Install equipment and materials in existing structures.
f. Upon written instructions from the Architect, uncover and restore Work to provide for Architect/Engineer observation of concealed Work.

C. Concrete Bases

1. Provide 4" high concrete housekeeping pads (unless otherwise noted) shall be provided under floor mounted mechanical equipment. Thicker pads are not allowed unless approved by engineer. Concrete inertia pads shall be provided for all base-mounted pumps and air compressors installed in the penthouse area.
2. Division 23 Contractor is to notify the General Contractor prior to submitting his bid, the number, size and location of all mechanical equipment bases. The Division 23 Contractor shall be liable for all associated costs to install the mechanical equipment bases upon failure to notify the General Contractor prior to bid submission.
3. Construct concrete equipment bases a minimum 4 inches larger in both directions than supported unit. Follow supported equipment manufacturer's setting templates for anchor bolt and tie locations. Use 3000 psi, 28-day compressive strength concrete, reinforcement and forms as specified in Division 3 Section "Cast-In-Place Concrete." Coordinate final equipment base size with General Contractor.

D. Roof curbs, roof support for mechanical equipment and roof penetrations.

1. Division 23 Contractor is to coordinate with the General Contractor all roof curb and roof supports supplied, number, size and location of all roof penetrations. All major roof penetrations are shown on the architectural roof plan. General Contractor shall be notified of all additional roof penetrations provided by the Division 23 Contractor not shown on this plan. The General Contractor shall provide all roof deck mounted equipment and pipe supports, pipe penetrations and cut roof deck for pipe and duct penetrations, unless noted otherwise. The Division 23 Contractor shall furnish all roof curbs and the General Contractor shall install, unless noted otherwise. The Division 23 Contractor shall provide all roof covering/membrane mounted equipment and pipe supports and roof drains, unless noted otherwise.
2. The Division 23 Contractor shall be liable for all associated costs to install the roof curbs, roof supports and roof penetrations not shown on the roof plan or added after the roof system has been installed. Coordinate with the General Contractor prior to construction the number size and location of all roof penetrations.
3. Division 23 Contractor is to coordinate with the General Contractor all roof curb and roof supports supplied, number, size and location of all roof penetrations. All major roof penetrations are shown on the architectural roof plan. General Contractor shall be notified of all additional roof penetrations provided by the Division 23 Contractor not shown on this plan.

E. Painting

1. The General Contractor is to field paint mechanical equipment and materials in specified areas as noted on the mechanical plans, mechanical schedules and in the specifications. Division 23 Contractor is to coordinate the painting of these items with the General Contractor. The Mechanical Contractor is to provide materials in these areas that are suitable for accepting paint. The clean and preparation of the materials to reach paint is the responsibility of the General Contractor unless noted specifically to be responsibility of the Division 23 Contractor.
2. In concealed locations, field-fabricated bare iron or steel items required for installation of work under this Division shall have rough or sharp edges removed and shall be painted with one coat of zinc rich paint.
3. In exposed locations, field-fabricated bare iron or steel items required for installation of work under this Division shall have rough or sharp edges removed and shall be painted in accordance with Section 09 91 00.

3.10 ELECTRICAL-MECHANICAL EXTENT OF WORK

A. The responsibility of work specified under Division 23 and 26 is clarified under, Section 23 05 13, "Electrical Requirements for Mechanical Equipment. Division 23 Contractor is to coordinate all electrical requirements prior to ordering powered mechanical equipment.

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SECTION 23 05 13
ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT

1. GENERAL

1.1 SECTION INCLUDES

A. Electrical Requirements for:

1. Motors
2. Starters, Electrical Devices, and Wiring
3. Manual Motor Starters
4. Motor Connections
5. Capacitors
6. Safety Switches

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

1. Electrical components and materials shall be UL labeled and listed.

B. References.

1. The design, manufacture, testing and method of installation of all equipment and materials furnished under the requirements of this specification section shall conform to the following:

a. AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings.
b. AFBMA 11 – Load Ratings and Fatigue Life for Roller Bearings.
c. ANSI/IEEE 112 – Test Procedure for Polyphase Induction Motors and Generators.
d. ANSI/NEMA Standard MG 1 – Motors and Generators.
e. ANSI/NFPA 70 - National Electrical Code.
f. NEMA Standard ICS 2 – Industrial Control Devices, Controllers, and Assemblies.
g. NEMA Standard 250 – Enclosures for Electrical Equipment.
h. NEMA Standard KS 1 – Enclosed Switches.

C. Submittals.

1. No separate submittal is required. Submit product data for motors, starters, and other electrical components with submittal data required for the equipment for which it serves, or as required by the individual equipment specification sections.

D. Operation and maintenance manuals.

E. Project record documents.

F. Delivery, storage, and holding

G. Related sections.

1. Separate electrical components and materials required for field installation and electrical connections are specified in Division 26.

1.3 SUMMARY

A. This section specifies the basic requirements for electrical components which are an integral part of packaged mechanical equipment. These components include, but are not limited to factory installed motors, starters, and disconnect switches furnished as an integral part of packaged mechanical equipment. In addition, this section covers necessary coordination issues between mechanical and electrical disciplines. All mechanical and electrical construction documents must be completely reviewed by the Mechanical and Electrical Contractors prior to the submission of bids. Any discrepancies in the documents should be brought to the Architect/Engineer's attention at that time. Failure to properly coordinate or review documents in advance of submission of bids will not be valid cause for changes to the overall Contract amount.

B. Specific electrical requirements (i.e. horsepower and electrical characteristics) for mechanical equipment are scheduled on the Drawings.

2. PRODUCTS

2.1 MOTORS

A. The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications.

1. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.
2. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range. Minimum service factors shall be as follows:

Motor Service Factor Schedule		
Horsepower:	**3600 RPM:**	**1800 RPM:**
1/6 – 1/3	1.35	1.35
1/2	1.25	1.25
3/4	1.25	1.25
1 – 1.25	1.25	1.15

1.5 - 150	1.15	1.15

3. Two-speed poly-phase motors shall have two separate windings served by a single point electrical connection to the two speed starter. Two speed starters shall be located at the motor location unless otherwise noted.
4. Temperature Rating: Rated for 40 deg. C environment with maximum 50 deg. C temperature rise for continuous duty at full load (Class A Insulation).
5. Starting capability: Frequency of starts as indicated by automatic control system, and not less than five (5) evenly timed starts per hour for manually controlled motors.
6. Motor construction: NEMA Standard MG 1, general purpose, continuous duty, Design "B", except "C" where required for high starting torque.

    a. Frames: NEMA Standard No. 48 or 54; use driven equipment manufacturer's standards to suit each specific application.
    b. Bearings: Ball or roller bearings with inner and outer shaft seals; re-greasable; designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor; for fractional horsepower, light duty motors, sleeve type bearings are permitted.
    c. Enclosure Type: Unless otherwise noted, use open drip-proof motors where satisfactorily housed or remotely located during operation; guarded drip-proof motors where exposed to contact by employees or building occupants; weather protected Type I for outdoor use, Type II where not housed.

    d. Overload protection: Built-in thermal overload protection (in accordance with NEC requirements) and, where indicated, an internal sensing device suitable for signaling and stopping the motor at the starter.

7. Noise rating: "Quiet"
8. Efficiency: **"Premium efficiency"** motors, as defined in NEMA MG 1, most recent edition.
9. Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.
10. All three-phase motors shall be inverter duty type.
11. Motors Used With Variable Frequency Drives: Ratings, characteristics, and features coordinated with and approved by drive manufacturer. Motor shall be designed and labeled for use with variable frequency drives. Motor shall be designed with critical vibration frequencies outside the operating range of the drive output and shall be suitable for use throughout speed range without overheating.

    a. Provide AEGIS SGR, or approved equivalent, shaft grounding ring/system to divert adverse shaft currents away from the motor bearings. Use AEGIS Colloidal Silver Shaft Coating (PN CS015), or approved equivalent, prior to ring installation. Install coating and ring per manufacturer recommendations.

2.2 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 shall be responsible for replacement sheaves required to achieve specified performance. Coordinate with testing and balancing of the equipment.

2.3 STARTERS, ELECTRICAL DEVICES, AND WIRING

A. Motor-Starter Characteristics: Motor starters shall be compatible with the equipment they serve. In general, motor starter characteristics shall meet the requirements of Division 26 specification sections and as outlined as follows:

B. Unless specifically approved in writing by the engineer, or as stated later in this paragraph, motor starters, VFDs and motor controllers (including equipment with integral motor starting) for motors shall have short circuit current ratings equivalent to the switchboard or electrical panel serving the load immediately upstream of the load. Refer to the electrical drawings for switchboard and electrical panel ratings. Provide additional overcurrent device protection if necessary to meet this requirement.

1. Exception: Where a motor or combination of motors is less than 10 horsepower in total and fed by more than 50 feet of wiring between the switchboard or panel that it is served by and the motor starter/controller/VFD, the starter/controller/VFD may have a short circuit current rating of 5000 Amps.

C. Motor Connections

1. Provide connections to motors in accordance with the requirements listed in the electrical specifications.
2. See Division 26 for the use of lugs for motor connections.

D. Capacitors

1. Capacitor features shall include:

a. Individual unit cells.
b. All welded steel housing.
c. Each capacitor shall be internally fused.
d. Non-flammable synthetic liquid impregnate.
e. Craft tissue insulation.
f. Aluminum foil electrodes

2. KVAR size shall be determined by the Contractor/Supplier and shall correct motor power factor to 95 percent or better and shall be installed on all motors 10 horsepower and larger that have an uncorrected power factor of less than 85 percent at rated load. Power factor correction is not required for motors used in conjunction with variable frequency drives.

E. FULL VOLTAGE NON-REVERSING MAGNETIC STARTERS

1. See specification section 26 29 13 – Motor Controllers for requirements.

F. FULL VOLTAGE NON-REVERSING COMBINATION STARTERS

1. See specification section 26 29 13 – Motor Controllers for requirements.

G. MANUAL MOTOR STARTERS

H. See specification section 26 29 13 – Motor Controllers for requirements.

I. CAPACITORS

1. Capacitor features shall include:

a. Individual unit cells.
b. All welded steel housing.
c. Each capacitor shall be internally fused.
d. Non-flammable synthetic liquid impregnate.
e. Craft tissue insulation.
f. Aluminum foil electrodes

2. KVAR size shall be determined by the Contractor/Supplier and shall correct motor power factor to 95 percent or better and shall be installed on all motors 10 horsepower and larger that have an uncorrected power factor of less than 85 percent at rated load. Power factor correction is not required for motors used in conjunction with variable frequency drives.

2.4 SAFETY SWITCHES

A. See specification section 26 05 01 – Basic Electrical Materials and Methods.

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

SECTION 23 05 19
HVAC METERS AND GAGES

1. GENERAL

1.1 SECTION INCLUDES

A. Sight flow indicators.

B. Pressure gages and pressure gage taps.

C. Thermometers and thermometer wells.

D. Piping pressure and temperature test plugs.

E. Static pressure and filter gages.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

B. References

C. Submittals

D. Operation and maintenance manuals.

E. Project record documents

1. Accurately record actual locations of instrumentation.

F. Delivery, storage, and handling

1.3 ENVIRONMENTAL REQUIREMENTS

A. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

2. PRODUCTS

2.1 SIGHT FLOW INDICATORS

A. Bronze or stainless-steel body, with sight glass and paddle wheel indicator, threaded or flanged ends.

B. Minimum pressure rating: 150 psig.

C. Minimum temperature rating: 200 deg F.

D. End connections for NPS 2 inch and smaller: Threaded.

E. End Connections for NPS 2-1/2 inch and larger: Flanged.

2.2 PRESSURE GAGES

A. Standard: ASME B40.200.

B. Type: General use, ASME B40.1, Grade A, phosphor bronze bourdon-tube type, bottom connection, liquid-filled.

C. Case: Drawn steel or brass, glass lens, 4-1/2-inches diameter.

D. Connector: Brass, 1/4-inch NPS.

E. Scale: White coated aluminum, with permanently etched markings.

F. Accuracy: Plus or minus 1 percent of range span.

G. Range: Conform to the following:

1. Vacuum: 30 inches Hg to 15 psi.
2. All fluids: 2 times operating pressure.

2.3 PRESSURE GAGE ACCESSORIES

A. Syphon: 1/4-inch NPS straight coil constructed of brass tubing with threads on each end.

B. Snubber: 1/4-inch NPS brass bushing with corrosion-resistant porous metal disc. Disc material shall be suitable for fluid served and rated pressure.

2.4 GLASS THERMOMETERS

A. Standard: ASME B40.200.

B. Case: Die cast, aluminum finished, in baked epoxy enamel, glass front, spring secured, 9 inches long.

C. Adjustable Joint: Finished to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.

D. Tube: Red reading, magnifying lens, with non-mercury fluid.

E. Scale: Satin-faced, nonreflective aluminum, with permanently etched markings.

F. Stem: Copper-plated steel, aluminum or brass, for separable socket, length to suit installation.

G. Accuracy: Plus or minus 1 percent of range span or plus or minus one scale division to maximum of 1.5 percent of range span.

H. Scale range: Temperature ranges for services listed as follows:

1. Condenser/Heat Pump Water: 0 to 160 deg F with 2-degree scale divisions (minus 18 to 70 deg C with 1-degree scale divisions).
2. Heating Water: 30 to 250 deg with 2-degree scale divisions (0 to 150 deg C with 1-degree scale divisions).
3. Chilled Water: 0 to 100 deg F with 2-degree scale divisions (minus 20 to 50 deg C with 1-degree scale divisions).
4. Steam and Condensate: 50 to 400 deg F with 2-degree scale divisions (0 to 200 deg C with 1-degree scale divisions).

2.5 THERMOMETER WELLS

A. Thermometer Wells: Brass or 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.

2.6 PIPING PRESSURE AND TEMPERATURE TEST PLUGS

A. Test Plugs shall be nickel-plated brass body, with 1/2-inch NPS fitting and 2 self-sealing valve-type core inserts, suitable for inserting a 1/8-inch O.D. probe assembly from a dial-type thermometer or pressure gage. Test plug shall have gasketed and threaded cap with retention chain and body of length to extend beyond insulation. Pressure rating shall be 500 psig.

B. Core Material: Conform to the following for fluid and temperature range:

1. Air, Water, Oil, and Gas, 20 to 200 deg F (minus 7 to 93 deg C): Neoprene.

2.7 STATIC PRESSURE GAGES

A. Inclined manometer, red liquid on white background with black figures, front recalibration adjustment, 3 percent of full scale accuracy.

B. Accessories: Static pressure tips with compression fittings for bulkhead mounting, 1/4 inch (6 mm) diameter tubing.

C. Construction: Bronze or stainless-steel body, with sight glass and [ball, flapper, or paddle wheel] <Insert device> indicator, and threaded or flanged ends.

D. Minimum Pressure Rating: [125 psig (860 kPa)] [150 psig (1034 kPa)] <Insert value>.

E. Minimum Temperature Rating: [200 deg F (93 deg C)] <Insert temperature>.

F. End Connections for NPS 2 (DN 50) and Smaller: Threaded.

G. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.

3. EXECUTION

3.1 GENERAL

A. Install in accordance with manufacturer's instructions.

3.2 FLOW MEASURING METERS

A. Install where shown on plans and schematics as indicated.

B. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions and as detailed on drawings.

C. Install flowmeter elements in accessible positions in piping systems. Maintain manufacturer-recommended minimum upstream and downstream distances.

D. Install permanent indicators on walls or brackets in accessible and readable positions.

E. Install connection fittings in accessible locations for attachment to portable indicators.

F. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

G. Install flow meters for piping systems located in accessible locations at most readable position.

H. Calibrate meter after installation in accordance with manufacturer's installation instructions.

I. Connect meters to EMCS. Coordinate with controls contractor and provide all necessary interconnections for accurate transmission of data.

J. Installation of steam meter and associated wiring, pressure transmitter and RTD assembly, shall be in strict accordance with manufacturer's printed instructions and recommendations, applicable BOCA requirements, and as detailed on drawings.

K. Swirl meters shall be installed in a horizontal position with a minimum of five straight pipe diameters upstream and three straight pipe diameters downstream. Meter head shall be installed in the horizontal plane or facing down as detailed in instructions for high temperature applications.

L. Swirl meter shall be installed prior to all steam pressure reducing valves and modulating control valves.

M. Pressure and temperature taps shall be installed a minimum of three pipe diameters downstream, before any isolation valves.

N. Swirl meter transmitter shall be located in an accessible location to permit ease of reading and service of transmitter.

O. Low-voltage wiring to the steam meter and flow computer shall be made in coordination with Energy Management Steam and Water Distribution personnel.

P. The final wiring connections to the swirl meter, pressure transmitter and RTD will be made by Energy Management Steam and Water Distribution personnel.

Q. Steam will not be turned on by Energy Management Steam and Water Distribution personnel until the steam meter is fully installed and operating satisfactorily and the downstream steam piping is successfully leak tested and secure.

R. Only Energy Management Steam and Water Distribution personnel will be authorized to turn steam service on or off.

3.3 PRESSURE GAGES

A. Install pressure gages in piping tee with pressure gage valve, located on pipe at most readable position.

B. Install as shown on plans, and elsewhere as indicated.

C. Pressure Gage Ball Valves: Install in piping tee with snubber. Install syphon in lieu of snubber for steam pressure gages.

3.4 THERMOMETERS

A. Install thermometers in vertical and tilted positions to allow reading by observer standing on floor.

B. Install as shown on plans and elsewhere as indicated.

C. Thermometer Wells: Install in piping tee where thermometers are indicated, in vertical position. Fill well with oil or graphite and secure cap.

3.5 TEST PLUGS

A. Test Plugs: Install where indicated, located on pipe at most readable position. Secure cap.

3.6 ADJUSTING AND CLEANING

A. Adjusting: Adjust faces of meters and gages to proper angle for best visibility.

B. Cleaning: Clean windows of meters and gages and factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touch-up paint.

END OF SECTION

SECTION 23 05 29
HVAC HANGERS AND SUPPORTS

1. GENERAL

1.1 SECTION INCLUDES

A. Pipe, ductwork, and equipment hangers, supports, anchors, saddles and shields.

B. Mechanical flashing.

C. Equipment curbs.

D. Mechanical sleeves and seals.

E. Flashing and sealing equipment and pipe stacks.

F. Sealants, firestop insulation, putty and compounds.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

B. References.

C. Submittals.

D. Operation and maintenance manuals.

E. Project record documents.

F. Delivery, storage, and handling.

2. PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

A. Hydronic Piping:

1. Conform to International Mechanical Code, ASME B31.9, ASTM F708, MSS SP58, MSS SP69 and MSS SP89 as applicable.

B. Steam and Steam Condensate Piping:

1. Conform to International Mechanical Code, ASME B31.9, ASTM F708, MSS SP58, MSS SP69, MSS SP89, as applicable.

C. Hangers and Supports:

1. Hangers for Hot and Cold Pipe Sizes 1/2 to 1-1/2 Inch, Carbon steel, adjustable swivel, band type.
2. Hangers for Cold Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
3. Hangers for Hot Pipe Sizes 2 to 4 Inches; Carbon steel, adjustable, clevis.
4. Hangers for Hot Pipe Sizes 6 Inches and Over: Adjustable steel yoke, cast iron roll, double hanger.
5. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
6. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 Inches and Over: Steel channels with welded spacers and hanger rods, cast iron roll.
7. Wall Support for Hot Pipe Sizes 6 Inches (150 mm) and Over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.
8. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
9. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp.
10. Vertical Support: Steel riser clamp.
11. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
12. Floor Support for Hot Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
13. Floor Support for Hot Pipe Sizes 6 Inches and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
14. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
15. Roof Support for Hot and Cold Pipe: See PIPE STANDS section below.
16. **Hangers for insulated pipe shall be enlarged to compensate for insulation thickness so that hangers support insulation. See Section 23 07 19.**
17. See Section 23 05 48 for vibration isolation hangers and supports if applicable.

2.2 DUCTWORK HANGERS AND SUPPORTS

A. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

B. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

C. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Exposed Stainless-Steel Ducts: Stainless-steel shapes and plates.

2.3 ACCESSORIES

A. Hanger Rods: ASTM A36 steel or galvanized threaded both ends, threaded one end, or continuous threaded.

1. Ductwork: Use double nuts and lock washers on threaded rod supports.

2.4 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Internally Threaded Screw Anchors: Internally threaded, self tapping screw anchors, Power Fasteners Snake or approved equivalent.

1. Tested in accordance with ACI 355.2 and ICC-ES AC193 for use in structural concrete under the design provisions of ACI318 (Strength Design method using Appendix D)

2.5 INSERTS

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

2.6 FLASHING

A. Metal Flashing: 26 gage galvanized steel.

B. Metal Counterflashing: 22 gage galvanized steel.

C. Lead Flashing:

1. Waterproofing: 5 lb/sq ft sheet lead
2. Soundproofing: 1 lb/sq ft sheet lead.

D. Flexible Flashing: 47 mil thick sheet buty; compatible with roofing.

E. Caps: Steel, 22 gage minimum; 16 gage at fire resistant elements.

2.7 EQUIPMENT CURBS

A. Fabrication: Welded 18 gage galvanized steel shell and base, mitered 3 inch cant, variable step to match roof insulation, 1-1/2 inch thick insulation, factory installed wood nailer. Minimum 18 inch height, unless specified otherwise.

2.8 SLEEVES

A. Sleeves for Pipes Through Non-fire Rated Floors: 18 gage galvanized steel.

B. Sleeves for Pipes Through Non-fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Steel pipe or 18 gage galvanized steel.

C. Sleeves for Round Ductwork: Galvanized steel.

D. Sleeves for Rectangular Ductwork: Galvanized steel.

2.9 SEALANTS, FIRESTOP INSULATION, PUTTY, AND COMPOUNDS

A. Firestopping Insulation: Glass fiber type, non-combustible, UL listed.

B. Firestop Putty: Non-harding, non shrinking, UL listed.

C. Firestop Compounds: Cementitous material, non-shrinking, UL listed.

D. Sealants:

1. Non fire/smoke rated partitions: Acrylic or silicone based caulking.
2. Fire/smoke rated partitions: Silicone based caulking, UL listed.

2.10 MECHANICAL SEALS

A. Mechanical Seals: Modular mechanical type, consisting of interlocking EPDM synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with type 316 stainless steel bolts and reinforced plastic polymer pressure plates which cause rubber sealing elements to expand when tightened, providing a watertight and gas-tight seal and electrical insulation. Provide Link-Seal or equivalent.

1. Provide high-temperature silicone links rated for 400 Deg. F for steam and condensate applications.

2. A sleeve shall be provided for each mechanical seal.

a. Thermoplastic sleeves: Sleeve shall have smooth walls and shall be made of molded non-metallic high density polyethylene (HDPE) with an integral solid water stop, Advance Products & Systems Model PWS or equivalent.
b. Steel sleeves: Sleeve shall have smooth walls, shall be made of Schedule 40 steel with an integral welded solid water stop, and shall have corrosion-resistant coating, Advance Products & Systems Model GWS or equivalent.

3. EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.2 INSERTS

A. Provide inserts for placement in concrete formwork.

B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.

D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

E. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.3 PIPE HANGERS AND SUPPORTS

A. Support horizontal piping as scheduled.

B. Support fire protection systems piping independently from other piping systems. Fire main piping may be trapezed with other piping systems. Coordinate trapeze hangers with the Sprinkler Contractor.

1. Reference sections 21 05 29 and 22 05 29 for additional information regarding fire protection and plumbing piping supports and hangers.

C. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.

D. Place hangers within 12 inches of each horizontal elbow.

E. Use hangers with 1-1/2 inch minimum vertical adjustment.

F. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.

G. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.

H. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

I. Support riser piping independently of connected horizontal piping.

J. Provide copper plated hangers and supports for non-insulated copper pipe.

K. Design hangers for pipe movement without disengagement of supported pipe.

L. Prime coat steel hangers and supports in the mechanical room and other exposed areas. Refer to the Architectural reflected ceiling plans for location of exposed ceilings. Hangers and supports located in attic space, crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

M. Adjust hangers to distribute loads equally on attachments and to achieve specified pipe slopes.

N. Saddles, Shields and Inserts

1. Install protection saddles MSS Type 39 where insulation without vapor barrier is indicated. Fill interior voids with segments of insulation that match adjoining pipe insulation.
2. Install protective shields MSS Type 40 on cold piping that has vapor barrier. Shields shall span an arc of 180 degrees (360 degrees on trapeze hangers with U-bolt clamps) and shall have dimensions in inches not less than the following:

NPS	LENGTH	THICKNESS
1 through 3-1/2	12	0.048
4	12	0.060
5 & 6	18	0.060
8 through 14	24	0.075
16 through 24	24	0.105

3. Insert materials shall be at least as long as the protective shield.
4. Provide manufacturer-recommended saddles, inserts, and/or shields where cellular foam insulation is used. The removal of sections of cellular foam insulation for the purpose of pipe support is not acceptable.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 INSTALLATION OF ANCHORS

A. Install anchors at proper locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and with AWS Standards D1.1.

C. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions to control movement to compensators.

D. Anchor Spacings: Where not otherwise indicated, install anchors at ends of principal pipe runs, at intermediate points in pipe runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.

3.6 FLASHING

A. Provide flexible flashing and metal counterflashing where piping and ductwork penetrate weather or waterproofed walls and floors.

B. Flash drains in floors with topping over finished area with lead, inches clear on sides with minimum 36 x 36 inch sheet size. Fasten to drain clamp device.

C. Seal floor, shower, mop sink, etc. drains watertight to adjacent materials.

D. Provide acoustical lead flashing around ducts and pipes penetrating equipment rooms, installed in accordance with manufacturer's instructions for sound control.

E. Adjust storm collars tight to pipe with bolts; caulk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.

3.7 SLEEVES

A. Provide pipe and duct sleeves at all fire/smoke rated partitions, exterior wall penetrations and wall penetrations into exposed areas. Pipe and duct sleeves are not required for penetrations through non-rated concealed partitions.

B. At the Contractor’s option, pipe sleeves may be omitted if the wall or floor is core drilled.

C. Set sleeves in position in formwork. Provide reinforcing around sleeves.

D. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.

E. Sleeves through floors shall be grinded flush with finish floor level.

F. Where piping or ductwork penetrate non-rated ceilings or walls, close off space between pipe or duct and adjacent work with urethane rod stock and caulk air tight.

G. Seal pipe and duct penetrations through non-rated floors.

1. Where piping is not located in a rated shaft and it penetrates a single non-rated floor, close off space between pipe and adjacent work with urethane rod stock and caulk air tight.
2. Where piping is not located in a rated shaft and it penetrates multiple non-rated floors, close off space between pipe and adjacent work with appropriate fire-rated sealant, insulation, putty, or compound.
3. Where ductwork is not located in a rated shaft and it penetrates a single non-rated floor, close off space between duct and adjacent work with appropriate fire-rated sealant, insulation, putty, or compound.
4. Where ductwork is not located in a rated shaft and it penetrates multiple non-rated floors, close off space between duct and adjacent work with appropriate fire-rated sealant, insulation, putty, or compound. Install fire damper in duct at each floor level. Ductwork containing fume exhaust air shall not be provided with fire dampers.

H. Where piping or ductwork penetrate rated floor, ceiling, or wall, close off space between pipe or duct with appropriate fire rated sealant, insulation, putty or compound. Refer to the Drawings for fire/smoke rated wall locations and the appropriate ratings.

I. Provide on ductwork close fitting metal collar or escutcheon covers on the side of penetration that are exposed to view.

J. Install chrome plated steel escutcheons on piping at finished surfaces.

K. Provide mechanical seals and sleeves through exterior wall and floor penetrations and 3 hour or higher fire rated partitions.

3.8 HANGER SCHEDULES

A. Reference International Plumbing Code and International Mechanical Code where applicable.

END OF SECTION

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SECTION 23 05 48
HVAC VIBRATION CONTROLS

1. GENERAL

1.1 Coordinate requirements of this specification with all other specifications and trades. Requirements of this specification take precedence over other specification sections. For example, the requirements of this section with regard to pipe supports in mechanical rooms take precedence above the requirements of Section 23 05 29.

1.2 This specification pertains to the furnishing and installation of vibration isolation devices for rotating or reciprocating mechanical equipment and piping and conduit systems attached thereto, and electrical transformers and attached switchgear and conduit systems.

1.3 This work shall include all material and labor required for installation of the resilient mounting and suspension systems, adjusting each mounting system, and measurement of isolator system performance when so requested by the Architect. Specific mounting arrangements for each item of mechanical and electrical equipment shall be as described herein and as indicated by schedules and details on the drawings.

1.4 All vibration isolation equipment except for resilient pipe connectors, including steel framing and reinforcing for concrete inertia bases and including steel rail bases, shall be furnished by Mason Industries or Kinetics Noise Control. A single manufacturer for all vibration isolation equipment in Sections 22 05 48, 23 05 48, and 26 05 48 will be required except as specifically approved in writing by the Architect or by his specific approval of shop drawings or as specified herein. For resilient pipe connectors refer to provisions of this specification that follow.

1.5 SECTION INCLUDES

A. Vibration isolation systems.

1.6 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING GUIDELINES

A. References

B. Submittals

C. Delivery, storage and handling

1.7 ADDITIONAL REQUIREMENTS

A. The Contractor and the vibration isolation manufacturer or his regularly designated and factory authorized representative shall perform the following tasks in addition to the supply and installation of isolation equipment:

1. Obtain from the Architect the approved manufacturer's name, model number, and other necessary identifying data for each item of mechanical and electrical equipment to be resiliently mounted. Coordinate all resilient mounting systems with the exact equipment to be furnished in regard to physical size, isolator locations, weight, rotating speed, etc. Direct contact and cooperation between the vibration isolation device fabricator and the equipment manufacturer will be required.
2. Obtain all necessary data in regard to piping systems which are to be resiliency supported so that proper isolators can be selected. Select piping system isolators for proper coordination with the physical arrangement of pipe lines and with the physical characteristics of the building.
3. Submit shop drawings as required by other portions of this specification. These drawings shall include specification information as follows:

    a. Manufacturer's model number for each isolator, the machine or pipeline to which it is to be applied, and the number of isolators to be furnished for each machine or pipeline.
    b. For steel spring mounts or hangers - Free height, deflected height, solid height, isolator loading, and diameter of spring coil.
    c. For elastomer or glass fiber isolators - Free height, deflected height, and isolator loading.
    d. Dimensional and weight data for concrete inertia bases, steel and rail bases, and details of isolator attachment.

4. Provide on-the-job supervision as required during installation of resiliently mounted equipment and piping to assure that all vibration isolators are installed in strict accordance with normally accepted practices for critical environments.
5. Replace at no extra cost to the Owner any isolators which do not produce the required deflection, are improperly loaded above or below their correct operating height, or which in any way do not produce the required isolation.
6. Cooperate with all other Contractors engaged in this project so that the installation of vibration isolation devices will proceed in a manner that is in the best interests of the Owner.
7. Notify the Architect of any project conditions which affect vibration isolation system installation or performance and which are found to be different from conditions indicated by the drawings or described by the specifications. Should vibration isolation system installation proceed without such notifications any remedial work required to achieve proper isolator performance shall be accomplished by the Contractor at no additional cost to the Owner.

8. Be alert for possible "short-circuiting" of vibration isolation systems by piping supports, electrical connections, temperature control connections, drain lines, building construction, etc., and notify the involved contractor as to these problems or potential problems. Where such situations cannot be easily resolved, notify the Architect so that preventive or remedial action can take place on a timely basis. Any remedial measures required shall be undertaken by the contractor responsible at no additional cost to the Owner.
9. This specification does not include provisions for seismic restraints that might be required by isolations systems due to the geographic location of the project, building codes, or other considerations.

2. PRODUCTS

2.1 VIBRATION ISOLATION SYSTEMS:

1. General:

   a. The vibration isolation systems described herein and identified by type letter designations shall be applied to specific classifications of mechanical and electrical equipment as indicated by Section C of this document.
   b. The minimum static deflection of the isolators for each classification of mechanical or electrical equipment shall be as indicated by Section C of this document or as otherwise indicated herein.

2. Type A Isolation:

   a. The equipment shall be rigidly mounted on a large reinforced concrete inertia base which has length and width dimensions approximately 20% greater than the supported equipment. The inertia base and equipment shall be supported by steel spring vibration isolators. Brackets for the spring isolators shall be located off the sides of the inertia base or integral with the perimeter of the inertia base with the tops of the springs near the vertical center of gravity of the equipment and inertia block; or if the center of gravity is higher than the top of the inertia base, the tops of the springs shall be at the top of the inertia base. The spring isolators shall rest on curbs or pedestals if necessary. There shall be a 2 inch minimum space between the bottom of the inertia base and the top of the housekeeping pad or floor slab when a housekeeping pad is not indicated to be employed.
   b. Concrete inertia bases shall be formed by a welded steel channel frame which incorporates prelocated equipment anchor bolts, and reinforcing bars in each direction welded in place. Concrete shall be standard 150-160 Ib/cu.ft. structural concrete. The base thickness shall be determined by the weight requirements but it shall be a minimum of 8% of the longest span between isolators or 6 inches, whichever is greater. For centrifugal and axial fans and centrifugal pumps the inertia base shall have a minimum weight equal to that of the isolated equipment. For reciprocating equipment the inertia base shall have a minimum weight equal to twice the weight of the equipment.

c. Springs shall be of the free standing unhoused type. Horizontal spring stiffness shall not be less than 0.8 of vertical stiffness. Springs shall be selected for reasonably uniform deflection taking into consideration any difference in machine weight at each supporting point, but deflection of each spring shall not be less than that specified for each classification of mechanical equipment. The spring deflection from the point of rated deflection to the point at which the spring is solid shall not be less than 1/2 of the rated static deflection. The yield point of the steel used in the springs shall be sufficiently great so that the springs may be compressed to shorted turns without danger of spring failure. At least two layers of ribbed waffle pattern neoprene pads or equivalent glass fiber pads shall be installed under the base plate of each spring isolator. Springs shall have leveling bolts and proper means for bolting to the machines. To prevent corrosion, springs for outdoor installation shall be galvanized or otherwise coated as approved by the Architect.

3. Type B Isolation:

a. The equipment shall be rigidly mounted on wide flange or channel structural steel members which shall run perpendicular to any support channels or similar members which are an integral portion of the equipment, or which shall be fabricated to form a complete frame for machine mounting. Height saving spring mounting brackets shall be welded to the ends of the structural steel saddle members or to the sides of structural steel frames to attach free standing steel spring isolators. Unless otherwise approved, the depth of the structural steel saddle members or the perimeter members of mounting frames shall be at least one-tenth of the longest frame dimension.
b. Steel spring isolators shall be as specified for Type A isolation.
c. Minimum clearance between the steel base and the housekeeping pad or floor shall be 2 inches.

4. Type C Isolation:

a. The equipment shall be rigidly mounted in a steel frame which is sufficiently stiff so that it may be supported on resilient isolators without distortion of the frame or misalignment of the equipment. If the equipment has an integral frame which is suitably rigid, the resilient isolators may be secured directly to the integral equipment frame or base.
b. Isolators shall be selected on the basis of the required static deflection as scheduled or otherwise indicated, and as follows:

1) Required deflection 0.25 to 0.4 inches - double deflection neoprene-in-shear isolators.
2) Required deflection 0.5 inches and greater - steel spring isolators as specified for the Type A mounting.

c. Isolators shall be selected for reasonably uniform deflection taking into consideration any difference in machine weight at each supporting point, but deflection shall not be less than that specified for each classification of equipment.
d. Minimum clearance between the equipment base and the house keeping pad or floor shall be 2 inches.

5. Type D Isolation:

a. The equipment shall be mounted on resilient "pads". These pads shall be multiple layers of waffle or ribbed neoprene, neoprene and cork sandwich, or precompressed glass fiber with height and stiffness as required to provide the static deflection as scheduled or specified and as required to properly support the load.
b. Pads shall be loaded in accordance with the manufacturer's recommendations and sized to achieve this recommended loading. The equipment weight at each sup porting point shall be considered in selecting pad dimensions along with the recommended loading.

3. EXECUTION

3.1 GENERAL

A. Install in accordance with manufacturer's instructions.

3.2 EXAMINATION

A. Examine areas and equipment to receive vibration isolation control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 VIBRATION-CONTROL DEVICE INSTALLATION

A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Equipment Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

C. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

D. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

E. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

F. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust active height of spring isolators.

C. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.5 RESILIENT MOUNTINGS FOR SPECIFIC CLASSIFICATIONS OF MECHANICAL EQUIPMENT:

EQUIPMENT	LOCATION	ESTIMATED MINIMUM ROTATING SPEED (RPM)	ISOLATION TYPE	MINIMUM ACTUAL STATIC DEFLECTION (INCHES)

Base Mounted Pumps	First Floor Mechanical Room	1800	C	3.0

3.6 ISOLATION OF PIPING SYSTEMS:

A. All piping and rigidly connected devices such as pressure reducing valves which connects to resiliently mounted equipment shall be suspended with resilient hangers or supported by floor mounted isolators for a distance of 100 pipe diameters from the connected machine or within the mechanical equipment room, whichever is the greater distance. The first three supports from the connected machine shall have the same static deflection as indicated for the machine; the next two supports shall have static deflection at least equal to one-half of the static deflection indicated for the machine mounting, and remaining pipe supports shall provide static deflection of 0.35 inches minimum. These remaining isolators may be elastomer.

B. Vertical pipe risers shall be resiliently mounted, preferably with each riser anchored near the center of the run. The risers shall be supported at the anchor points with steel spring or double deflection neoprene-in-shear isolators which provide static deflection of at least 0.35 inches. Isolators for the remainder of each run shall be steel spring type specifically designed to control load shifting due to pipe expansion and contraction. At least 0.35 inches deflection shall be maintained under all conditions.

C. Flexible synthetic rubber connectors shall be used to connect all piping to all isolated equipment. Flexible synthetic rubber connectors shall be fabricated using peroxide cured EPDM synthetic rubber and Kelvar tire cord reinforcement and shall be Mason Industries Safeflex of the most current design. Resilient connectors shall be selected for the pressure rating and temperature rating appropriate for the particular piping and pipe contents. Where synthetic EPDM flexible connectors are not permitted by code due to pipe contents and/or pressures provide swing pipe connectors changing direction a minimum of 3 times before joining isolated equipment. Swing connections should be made within approximately 6 feet of the isolated equipment.

D. Drain connections from isolated equipment to floor drains shall be at least 1" free from drain or use rubber hose.

3.7 ISOLATION OF FRACTIONAL HORSEPOWER EQUIPMENT:

A. All fractional horsepower fans, pumps, etc., which are mounted on or suspended from floors that are not on-grade shall be isolated with neoprene-in-shear isolators furnished by the vibration isolation supplier except where such isolators are furnished as an integral part of the machine.

END OF SECTION

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SECTION 23 05 53
HVAC IDENTIFICATION

1. GENERAL

1.1 SECTION INCLUDES

A. Nameplates.

B. Tags.

C. Pipe Markers.

D. Duct Markers.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

B. References.

C. Submittals.

D. Operation and maintenance manuals.

E. Project record documents

1. Record actual locations of tagged valves.

F. Delivery, storage, and handling.

2. PRODUCTS

2.1 NAMEPLATES

A. Equipment Mark Nameplates: Laminated three-layer plastic with engraved black letters (matching equipment mark indicated on drawings) on light contrasting background color, with minimum 3/4 inch high letters.

B. Equipment Nameplates: Factory-applied permanent nameplate indicating the manufacturer's name, model, serial number, temperature and pressure design, and any other data necessary

to conform with specified requirements. On equipment installed outdoors, nameplate shall be stamped steel or engrave plastic.

2.2 TAGS

A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter or square.

B. Chart: Typewritten list that is plastic laminated and mounted in mechanical room. Valve list is to coordinate with mechanical piping schematics if provided on plans.

C. Pipe Schematics: Valve numbers are to be labeled on Engineer schematic drawings, plastic laminated and schematic shall be mounted in mechanical room.

2.3 PIPE MARKERS

A. Color: Conform to ASME A13.1, latest revision

B. Plastic Tape Pipe Markers: Minimum 1-1/2" letter size and 2-mil thickness, flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings; minimum information indicating flow direction arrow and identification of fluid being conveyed.

C. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4-mil thick, manufactured for direct burial service. Provide tape with printing which most accurately indicates the type of service of buried pipe.

2.4 DUCT MARKERS

A. Plastic Tape Duct Markers: Minimum 1-1/2" letter size and 2-mil thickness, flexible, vinyl film tape with pressure sensitive adhesive backing and printed marking; minimum information indicating flow direction arrow and identification of air system being conveyed.

3. EXECUTION

3.1 PREPARATION

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

3.2 INSTALLATION

A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

B. Install tags with corrosion resistant chain.

C. Install plastic tape pipe and duct markers in accordance with manufacturer's instructions. Directional arrow tape shall be overlapped to ensure proper adhesion and no peeling of tape in future.

D. Identify air handling units, exhaust fans, chillers, pumps, heat generating, heat rejecting, heat transfer equipment, tanks, and water treatment devices with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.

E. Identify pressure reducing valves, backflow preventers, valves, and meters with tags.

F. Identify control panels and major control components outside panels with plastic nameplates.

G. Identify valves in main and branch piping with tags.

H. Tag automatic controls, instruments, and relays. Key to control schematic.

I. Identify piping, concealed or exposed, with plastic tape pipe markers. Identify service, flow direction, and pressure when applicable, i.e. low pressure steam, high pressure steam. Install in clear view from floor and align with axis of piping. Locations of identification not to exceed 15 feet on straight runs including risers and drops, more often in congested areas, adjacent to each valve and tee, at each side of penetration of structure or enclosure, and at each obstruction. Provide a minimum one label per pipe per room. Where pipes are racked, install pipe markers on each pipe in the same location to aid in differentiating each pipe in the rack.

J. Identify ductwork with plastic tape duct markers. Identify service, flow direction and pressure when applicable, i.e. low pressure supply air, high pressure supply air. Install in clear view from floor and align with centerline of duct. Locations of identification not to exceed 15 feet from straight runs including risers and drops, more often in congested areas, at each side of penetration of structure or wall, and at each obstruction. When several ducts from different units are located in concealed congested areas, locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.

END OF SECTION

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SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Special Conditions apply to this section.

1.2 DESCRIPTION OF WORK

A. This scope of services specifies the requirements and procedures for mechanical systems testing, adjusting, and balancing. Requirements include measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results. The test and balance work will be performed by the Owner's personnel. It is the Contractor's responsibility to assist as outlined below.

B. Test, adjust and balance the following mechanical systems which are shown in the construction documents.

1. Supply air systems, all pressure ranges, including variable volume and constant volume systems.
2. Exhaust air systems.
3. Hydronic systems.
4. Steam distribution systems.
5. Verify temperature control system operation.
6. Plumbing water systems (i.e. recirculation pumps, booster pumps).

C. The contractor's responsibilities are as follows:

1. Notify the Owner's Representative twenty-one (21) days prior to the schedule date for balancing the system.
2. Schedule a two (2) week allowance for the testing and balancing firm to complete the testing and balancing work when scheduling completion of all work required of the Contractor by the contract documents.
3. Cooperate with the testing and balancing firm and shall make all necessary preparations for the TAB efforts.
4. Complete the following work prior to requesting the TAB effort.

    a. Clean and flush all piping systems.
    b. Leak test and make tight all piping systems.
    c. Fill all piping systems with clean water.
    d. Clean and seal all ductwork systems.
    e. Service and tag all equipment.

f. Set and align all motors and drives.
g. Start up and prove all equipment and systems.
h. Make preliminary settings on all control devices and have all systems operational.
i. Operate all systems successfully for twenty-four (24) hours minimum.

5. Lubricate all motors and bearings.
6. Check fan belt tension.
7. Check fan rotation.
8. Patch insulation, ductwork and housing, using materials identical to those removed 9.
9. Seal ducts and piping, and test for and repair leaks.
10. Seal insulation to re-establish integrity of the vapor barrier.
11. Attend a coordination meeting prior to the balancing of the system and a coordination meeting following the balancing of the system.
12. Provide a complete set of as-built drawings prior to the TAB effort.
13. Provide craftsmen of the proper trade to work with the TAB firm to make adjustments and installation changes as required.
14. Change out fan sheaves when and if required by the TAB firm.
15. Dedicate the resources to accommodate all changes identified by the test and balance firm in a timely manner.
16. If a significant rebalance (Owner's determination) of the HVAC system is required due to the Contractor's failure to properly install and check out the HVAC system, the cost of rebalancing the system shall be borne by the Contractor.

1.3 PRE-BALANCING CONFERENCE

A. Prior to beginning of the testing, adjusting and balancing procedures, a conference with the Owner's representative, Engineer and the Test and Balance Agency's representative will be held. The objective of the conference is final coordination and verification of system operation and readiness for testing, adjusting and balancing.

1.4 SEQUENCING AND SCHEDULING OF SERVICES

1.5 Test, adjust and balance the air conditioning systems during summer season and heating systems during winter season. This includes at least a period of operation at outside conditions within 5 deg. F wet bulb temperature of maximum summer design condition, and within 10 deg. F dry bulb temperature of minimum winter design conditions. Take final temperature readings during seasonal operation.

2. PART 2 – PRODUCTS

2.1 PRODUCTS (Not applicable)

3. PART 3 – EXECUTION

3.1 GENERAL (Not applicable)

END OF SECTION

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SECTION 23 07 13
DUCTWORK INSULATION

1. GENERAL

1.1 SECTION INCLUDES

A. Ductwork insulation.

B. Insulation jackets.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. References.

B. Submittals.

C. Delivery, Storage, and Handling.

D. Quality assurance.

1. Materials: ASTM E84 Flame spread/smoke developed rating of 25/50 or less.

E. Qualifications.

1. Applicator: Company specializing in performing the work of this section with minimum three years experience.

F. Environmental requirements.

1. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
2. Maintain temperature during and after installation as recommended by the manufacturer.

2. PRODUCTS

2.1 GLASS FIBER, FLEXIBLE

A. Insulation: ASTM C553; flexible, noncombustible blanket.

1. 'K' value: ASTM C518, 0.30 at 75 degrees F.

2. Maximum service temperature: 250 degrees F.
3. ASTM C1104 Water Vapor Sorption less than 5% by weight
4. Density: 1.5 lb/cu ft.

B. Vapor Barrier Jacket

1. Vapor Retarder Jacket: FSK or PSK confirming to ASTM C 1136 Type I, II.
2. Moisture vapor transmission: ASTM E96; 0.02 perm maximum.
3. Secure with pressure sensitive tape.

C. Vapor Barrier Tape

1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

D. Tie Wire: Annealed steel, 16 gage (1.5 mm).

2.2 GLASS FIBER, RIGID

A. Insulation: ASTM C612; rigid, noncombustible blanket.

1. 'K' value: ASTM C518, 0.23 at 75 degrees F.
2. Maximum service temperature: 250 degrees F.
3. Maximum moisture absorption: less than 3 percent by volume.
4. Density (concealed locations): 3.0 lb/cu ft.
5. Density (exposed locations): 6.0 lb/cu ft.

B. Vapor Barrier Jacket

1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
2. Moisture vapor transmission: ASTM E96; 0.02 perm.
3. Secure with pressure sensitive tape.

C. Vapor Barrier Tape

1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive acrylic based adhesive.

2.3 EXTERIOR DUCT INSULATION

A. Laminated Cellular Foam; closed cell foam insulation with metal covering.

1. 'K' ('ksi') Value: ASTM C177 or C518; 0.25 at 75 degrees F.

2. Minimum Service Temperature: -297 degrees F.
3. Maximum Service Temperature: 180 degrees F.
4. Maximum Moisture Absorption: ASTM D209; 0.2 percent by volume.
5. Moisture Vapor Transmission: ASTM E96; 0.05 perm-inches.
6. Connection: Waterproof vapor barrier adhesive.
7. Armaflex Armatuff Sheet Insulation or equivalent.

B. Polyisocyanurate Foam Sheathing: ASTM C1289; Foil-faced uniform closed-cell board. Johns Manville AP Foil-Faced or equivalent.

1. 'R' Value: 9.0 at 1-1/2" board thickness.
2. Minimum Service Temperature: -100 degrees F.
3. Maximum Service Temperature: 250 degrees F.
4. Moisture Vapor Transmission: ASTM E96; 0.03 perm-inches.
5. Connection: Waterproof vapor barrier adhesive.
6. Field applied jacketing: MFM FlexClad 400 or equivalent; 40 mil thickness.

a. Aluminum jacket with high-density cross-linked polymer film.
b. Aggressive Asphalt adhesive.

3. EXECUTION

3.1 EXAMINATION

A. Verify that ductwork has been tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

A. Install materials in accordance with manufacturer's instructions.

B. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

C. Continue insulation through walls, sleeves, hangers, and other duct penetrations.

D. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.

E. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.

F. Secure insulation without vapor barrier with staples (staples only work well when there is a facing present), tape, or wires.

G. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift ductwork off trapeze hangers and insert spacers.

H. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.

I. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

J. Do not overtighten and/or compress flexible glass fiber duct insulation.

K. At duct access doors or other openings, insulation shall be properly framed and finished.

L. Take adequate pre-cautions to assure that the duct insulation does not get wet if installed before the building is enclosed

M. Provide All Service Jacket on duct insulation to be painted.

N. Duct wrap on horizontal ducts shall be pinned on the bottom and sides of the duct at 18" intervals to prevent sagging.

O. Do not insulate until duct leakage test is complete and acceptable.

P. At connections to equipment such as VAV boxes, all collars, reheat coils, coil return bends shall be insulated as the adjacent duct. All components in contact with 55F supply air shall be insulated and a vapor barrier installed.

Q. Provide neatly beveled edge at interruptions of insulation. Coat bare edges of insulation with mastic or sealant to prevent delamination.

R. Maintain integrity of vapor-barrier on ductwork insulation, and protect it to prevent puncture and other damage.

S. Install corner angles on external corners of insulation on ductwork in exposed mechanical or finished spaces before covering with jacketing.

T. Exterior Insulation Application:

1. Laminated closed cell foam:

a. Install in accordance with manufacturer's recommendation.

b. Utilize product compliant adhesives or pre-applied pressure sensitive adhesives.
c. Cover seams with product compliant seal tape.

2. Polyisocyanurate:

a. Install in accordance with manufacturer's recommendation.
b. Use product compliant adhesive for board installation
c. Taper insulation on top of ductwork to allow positive drainage.
d. Field-apply jacketing using pressure-sensitive adhesive and hand roller.
e. Install jacketing continuous across bottom of ductwork extending minimum 6" up each side of duct. Pin duct bottoms over 36" in width.

3.3 GLASS FIBER DUCTWORK INSULATION SCHEDULE

Ductwork Application:	**Type:**	**Thickness:**	**Vapor Barrier Required (Y/N):**
Exposed rectangular supply air duct in mechanical rooms and chases	Rigid	2"	Y
Exposed round supply air duct in mechanical rooms	Flexible	2"	Y
Exposed rectangular and round exhaust air duct	None required unless shown on plans		
Exposed rectangular and round supply air duct upstream of terminal units	Flexible	2"	Y
Exposed rectangular supply air duct downstream of terminal units	Flexible	2"	Y
Exposed round supply air duct downstream of terminal units	Flexible	2"	Y
Concealed rectangular and round supply air duct upstream of terminal units	Flexible	2"	Y
Exterior Ductwork	Exterior	2"	Y
Concealed exhaust air duct	None required unless shown on plans		

Schedule Notes:

A. All ductwork in mechanical rooms shall be insulated as though it were "Exposed".

END OF SECTION

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SECTION 23 07 16
HVAC EQUIPMENT INSULATION

1. GENERAL

1.1 SECTION INCLUDES

A. Equipment insulation.

B. Jacketing and accessories.

C. Breeching insulation.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. References.

B. Submittals.

C. Quality Assurance.

1. Materials: Flame spread/smoke developed rating of 25/50 in accordance with ASTM E84, NFPA 255 and UL 723.

D. Delivery, Storage, and Handling.

E. Environmental Requirements

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

2. PRODUCTS

2.1 GLASS FIBER, FLEXIBLE

A. Insulation: ASTM C553; flexible, noncombustible.

1. 'k' ((btu*in)/(hr*ft^2*deg F)) value : ASTM C335

Temperature (degrees F)	Maximum 'k' value (btu*in)/(hr*ft^2*deg F))
75	0.23
100	0.24
150	0.25
200	0.28
300	0.34
400	0.42
500	0.51

2. Maximum service temperature: 250 degrees F.
3. Maximum moisture absorption: 0.2 percent by volume.
4. Density: 2.0 lb/cu ft.

B. Vapor Barrier Jacket

1. ASTM C921, kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
2. Moisture vapor transmission: ASTM E96; 0.02 perm.
3. Secure with self sealing longitudinal laps and butt strips.
4. Secure with outward clinch expanding staples and vapor barrier mastic.

C. Tie Wire: 18 gage stainless steel with twisted ends on maximum 12 inch centers.

D. Vapor Barrier Lap Adhesive: compatible with insulation.

E. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

2.2 JACKETS

A. Canvas Jacket

1. Fabric: ASTM C921, 6 oz/sq yd, plain weave cotton treated with dilute fire retardant lagging adhesive.
2. Lagging Adhesive: Compatible with insulation.

B. Aluminum Jacket: ASTM B209.

1. Thickness: 0.040 inch.
2. Finish: Smooth.
3. Joining: Longitudinal slip joints and 2 inch laps.
4. Fittings: PVC pre molded fittings.
5. Metal Jacket Bands: 3/8 inch wide; 0.010 inch thick stainless steel.

3. EXECUTION

3.1 EXAMINATION

A. Verify that equipment has been tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

A. Install materials in accordance with manufacturer's instructions.

B. Painting of cellular foam insulation is not allowed.

C. Do not insulate factory insulated equipment.

D. On exposed equipment, locate insulation and cover seams in least visible locations.

E. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Secure insulation to equipment with studs, pins, clips, adhesive, wires, or bands.

F. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier cement.

G. Insulated dual temperature equipment or cold equipment containing fluids below ambient temperature:

1. Provide vapor barrier jackets, factory applied or field applied.
2. Finish with glass cloth and vapor barrier adhesive.
3. Insulate entire system.

H. For insulated equipment containing fluids above ambient temperature:

I. Provide standard jackets, with or without vapor barrier, factory applied or field applied.

1. Finish with glass cloth and adhesive.
2. For hot equipment containing fluids do not insulate flanges and unions, but bevel and seal ends of insulation.

J. Inserts and Shields:

1. Application: equipment 1-1/2 inches diameter or larger.
2. Shields: galvanized steel between hangers and inserts.
3. Insert location: between support shield and equipment and under the finish jacket.
4. Insert configuration: minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
5. Insert material: ASTM C640 cork, hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.

K. Finish insulation at supports, protrusions, and interruptions.

L. For equipment in mechanical equipment rooms or in finished spaces, finish with jacket sized for finish covering.

M. Do not insulate over nameplate or ASME stamps. Bevel and seal insulation around such.

N. Install insulation for equipment requiring access for maintenance, repair, or cleaning, in such a manner that it can be easily removed and replaced without damage.

3.3 TOLERANCE

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

3.4 GLASS FIBER, FLEXIBLE INSULATION SCHEDULE

A. Heating Systems

Equipment:	Thickness (inches):
Air separators	2"

END OF SECTION

SECTION 23 07 19 - HVAC PIPING INSULATION

1. GENERAL

1.1 SECTION INCLUDES

A. Piping insulation.

B. Jackets and accessories.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

1. Materials: Flame spread/smoke developed rating of 25/50 or less in accordance with ASTM E84, NFPA 255, and UL 723.

B. References.

C. Submittals.

D. Operation and maintenance manuals.

E. Project record documents.

F. Environmental requirements

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

2. PRODUCTS

2.1 GLASS FIBER

A. Insulation: ASTM C547; rigid molded, noncombustible.

1. 'k' ((btu*in)/(hr*ft^2*deg F)) value : ASTM C335

Temperature (degrees F)	Maximum 'k' value (btu*in)/(hr*ft^2*deg F))

75	0.23
100	0.24
150	0.25
200	0.28
300	0.34
400	0.42
500	0.51

2. Minimum Service Temperature: 0 degrees F.
3. Maximum Service Temperature: 1000 degrees F.
4. Maximum Moisture Absorption: 0.2% by volume.

B. Vapor Barrier Jacket

1. ASTM C1136, White kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
2. Moisture Vapor Transmission: ASTM E96; 0.02 perms.
3. Secure with self sealing longitudinal laps and butt strips.
4. Secure with outward clinch expanding staples and vapor barrier mastic.

C. Vapor Barrier Lap Adhesive: MIL-A-3316C, Class 2, Grade A compliant. Compatible with insulation. VOC Limit 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Insulating Cement: ASTM C195; hydraulic setting on mineral wool. VOC Limit 70 g/L (multipurpose construction adhesive).

E. Fibrous Glass Fabric: Cloth, untreated; 9 oz/sq yd weight with 1.0 lb/cu ft density blanket.

F. Indoor Vapor Barrier Finish: Vinyl emulsion type acrylic, compatible with insulation, white color. VOC Limit 50 g/L.

2.2 JACKETS

A. PVC Plastic

1. Jacket: ASTM C921, One piece molded type fitting covers and sheet material, white color.

    a. Minimum Service Temperature: 0 degrees F.
    b. Maximum Service Temperature: 150 degrees F.
    c. Moisture Vapor Transmission: ASTM E96; 0.002 perm inches.
    d. Maximum Flame Spread: ASTM E84; 25.
    e. Maximum Smoke Developed: ASTM E84; 50.
    f. Thickness: 20 mil.
    g. Connections: Brush on welding adhesive or pressure sensitive color matching vinyl tape.

2. Covering Adhesive Mastic: Compatible with insulation and PVC jacket. VOC Limit 50 g/L according to 40 CFR 59, Subpart D (EPA Method 24).

B. Aluminum Jacket: ASTM B209.

1. Thickness: 0.040 inch.
2. Finish: Smooth.
3. Joining: Longitudinal slip joints and 2 inch laps.
4. Fittings: PVC pre molded fittings.
5. Metal Jacket Bands: 3/8 inch wide; 0.010 inch thick stainless steel.

3. EXECUTION

3.1 EXAMINATION

A. Verify that piping has been tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

A. Install materials in accordance with manufacturer's instructions.

B. Painting of cellular foam insulation is not allowed.

C. On exposed piping, locate insulation and cover seams in least visible locations. For cellular foam insulation tape ALL visible seams with tape matching insulation color.

D. Fiberglass insulated dual temperature pipes or cold pipes conveying fluids below ambient temperature:

1. Provide vapor barrier jackets, factory applied or field applied.
2. Insulate fittings, joints, flanges, unions, strainers, flexible connectors, and valves with molded insulation of like material and thickness as adjacent pipe. PVC or aluminum covers are required in all exposed locations as in mechanical rooms.
3. Finish with glass cloth and vapor barrier adhesive.
4. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations.
5. Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.

E. Cellular foam insulated dual temperature pipes or cold pipes conveying fluids below ambient temperature:

1. Insulate fittings, joints, flanges, unions, strainers, flexible connectors, and valves with molded insulation of like material and thickness as adjacent pipe. PVC or aluminum covers are required in all exposed locations as in mechanical rooms.
2. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations.
3. Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.

F. Fiberglass insulated pipes conveying fluids above ambient temperature:

1. Provide vapor barrier jackets, factory applied or field applied.
2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. PVC covers are required in all exposed locations.
3. Finish with glass cloth and adhesive.
4. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations.
5. For hot piping conveying fluids, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
6. For steam and condensate piping, insulate flanges and unions.

G. Inserts and Shields:

1. Refer to Section 23 05 29 for additional information.
2. Application: Piping 1 inch diameter or larger.
3. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
4. Insert Location: Between support shield and piping and under the finish jacket.
5. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
6. Insert Material: ASTM C640 cork, hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.

7. Provide inserts and/or shields per manufacturer recommendations for cellular foam insulation applications in order to maintain continuous insulation throughout the pipe system. The removal of sections of cellular foam insulation to accommodate pipe supports is not acceptable. Manufacturer products specifically designed for supporting insulation and maintaining the integrity of the insulation system at pipe hanger locations, such Armaflex Armafix Insulation Pipe Hangers, are acceptable.

H. Finish insulation at supports, protrusions, and interruptions.

I. For pipe exposed below 6 feet above finished floor, finish with PVC jacket and PVC fitting covers.

J. For piping exposed in mechanical rooms below 6 feet above finished floor, finish with aluminum jacket and aluminum fitting covers.

K. All valves in insulated systems shall have valve stem extensions. Insulation installer shall notify the contractor and Owner if valves without stem extensions are encountered. All valves without stem extensions in areas where stem extensions are required shall be replaced.

L. Install insulation blanket on steam and condensate valves.

M. In Mechanical Rooms, insulate all heat piping and accessories. All accessories shall be insulated with removable covers.

N. Provide removable covers and insulation on strainers and manual or automatic flow control valves

O. Provide insulation clearance and access to valves and fittings in hangers and from structure and other equipment. Insulation shall be continuous through all hangers and supports. Refer to Section 23 07 19.

3.3 GLASS FIBER INSULATION SCHEDULE

A. Heating Systems

PIPING SYSTEM:	PIPE SIZE:	THICKNESS:
Heating Water Supply and Return	1-1/4" & smaller	1-1/2"
Heating Water Supply and Return	1-1/2" & larger	2"
Air Terminal Unit Reheat Coil Return Bends	1-1/4” & smaller	1-1/2”
Air Terminal Unit Reheat Coil Return Bends	1-1/2” & larger	2”

Low Press. (15 psig) Steam/Cond. Piping	2-1/2" & smaller	2-1/2"
Low Press. (15 psig) Steam/Cond. Piping	3" & larger	3"

END OF SECTION

SECTION 23 09 00
DIGITAL CONTROL EQUIPMENT

1. GENERAL

1.01 SUMMARY

A. University of Missouri Controls Specification.

B. This section contains requirements for pneumatic, electric and digital control systems as indicated on the contract drawings.

C. Contractor is responsible for providing, installing and connecting all sensors, pneumatic actuators, control valves, control dampers, electrical components and all interconnecting pneumatic tubing and electrical wiring between these devices and up to the Direct Digital Controller (DDC).

D. DDC systems consist of Johnson Controls METASYS controllers. Contractor shall install owner provided control enclosures. Owner will provide and install controllers. After all equipment has been installed, wired and piped, Owner will be responsible for all termination connections at the DDC controller's and for checking, testing, programming and start-up of the control system. Contractor must be on site at start-up to make any necessary hardware adjustments as required.

E. Once each mechanical system is completely operational under the new control system, contractor shall make any final connections and adjustments. For controls renovation jobs, contractor shall remove all unused sensors, operators, panels, wiring, tubing, conduit, etc. Owner shall have the option of retaining any removed pneumatic controls.

1.02 RELATED SECTIONS

A. Drawings and general provisions of Contract, including General and Special Conditions apply to work of this section.

1.03 QUALITY ASSURANCE

A. Contractor's Qualifications:
   1. Contractor shall be regularly engaged in the installation of digital control systems and equipment, of types and sizes required. Contractor shall have a minimum of five years' experience installing digital control systems. Contractor shall supply sufficient and competent supervision and personnel throughout the project in accordance with General Condition's section 3.4.1 and 3.4.4.

B. Codes and Standards:
   1. Electrical Standards: Provide electrical components of control systems which have been UL-listed and labeled, and comply with NEMA standards.
   2. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for control systems.
   3. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.
   4. NFPA Compliance: Comply with NFPA 70 "National Electric Code."

1.04 SUBMITTALS

A. Shop Drawings: Submit shop drawings for each control system, containing the following information:

B. Product data for each damper, valve, and control device.

C. Schematic flow diagrams of system showing fans, pumps, coils, dampers, valves, and control devices.

D. Label each control device with setting or adjustable range of control.

E. Indicate all required electrical wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

F. Provide details of faces on control panels, including controls, instruments, and labeling.

G. Include written description of sequence of operation.

H. Provide wiring diagrams of contractor provided interface and I/O panels.

I. Provide field routing of proposed network bus diagram listing all devices on bus.

2. PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Air Piping:
   1. Copper Tubing: Seamless copper tubing, Type M or L, ASTM B 88; wrought-copper solder-joint fittings, ANSI B16.22; except brass compression-type fittings at connections to equipment.
   2. Flex Tubing: Virgin Polyethylene non-metallic tubing, ASTM D 2737, with flame-retardant harness for multiple tubing. Use compression or push-on polyethylene fittings. Tubing used above suspended ceilings to be plenum rated per NFPA 90A. See section 3.1.b for locations where flex tubing can be used.

3. Copper to polyethylene connections shall be compression barbed fittings or solder barbed fittings.

B. Conduit and Raceway:
1. Electrical Metallic Tubing: EMT and fittings shall conform to ANSI C80.3.
2. Surface Metal Raceway and Fittings: Wiremold 500, Ivory, or approved equal.
3. Flexible Metal Conduit: Indoors, per National Electric Code for connection to moving or vibrating equipment.
4. Liquidtight Flexible Conduit: Outdoors, per National Electric Code for connection to moving or vibrating equipment.

C. Control Valves: Provide factory fabricated pneumatic or electric control valves of type, body material, and pressure class as indicated on the drawings. Butterfly style control valves are not acceptable except for two position applications. Equip control valves with heavy-duty actuators, with proper shutoff rating for each individual application.
1. Steam and Hot Water
a) Manufacturer: Do not allow KMC valves and actuators.
b) Water Service Valves: Equal percentage characteristics.
c) Steam Service Valves: Equal percentage characteristics.
d) Single Seated Valves: Cage type trim, providing seating and guiding surfaces for plug on "top and bottom" guided plugs.
e) Valve Trim and Stems: Polished stainless steel.
f) Packing: Spring-loaded Teflon, self-adjusting.
g) Control valves should have a minimum 100 psi close-off rating for chilled water applications.
2. Hydronic Chilled Water and Heating Water

1. General:

a. The control valve assemblies shall be provided and delivered from a single manufacturer as a complete assembly. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.
b. Valves shall be suitable for use in systems with glycol solution fluids.
c. Two-way valves shall have modified equal percentage characteristics. Three-way valves shall have linear characteristics.
d. Close-Off Pressure Rating: 100 psig minimum, but no less than 150% of the total system head.
e. Sizing:

1) Two-Position: Line size or size using a pressure differential of 1 psi.
2) Two-Way Modulating: 3 psig or twice the load pressure drop, whichever is higher.
3) Three-Way Modulating: Twice the load pressure drop, but not more than 5 psig.

2. Up to 3 inches:

a. Ball Valves: Nickel-plated forged brass body rated at no less than 400 psi, stainless steel ball and blowout proof stem, female NPT end fittings, with a dual EPDM O-ring packing design, fiberglass reinforced Teflon seats and a Tefzel ETFE or equivalent flow characterizing disc.

3. Over 3 inches:

a. Butterfly Valves: Butterfly valve body, full-lugged cast iron or ductile iron 200 psig body with a 304 stainless steel disc, EPDM seat, extended neck, meeting ANSI Class 125/150 flange standards. Disc-to-stem connection shall utilize an internal spline. The shaft shall be supported at four locations by RPTFE bushings.

1) Close-Off Pressure Rating: 200 psig bubble-tight shutoff for sizes 2" to 12"; 150 psig bubble-tight shutoff for sizes 14" and larger.

b. Globe Valves: ANSI Class 125 cast iron body, stainless steel stem, bronze plug, bronze seat, and a TFE V-ring packing.

4. Pressure Independent Hydronic Control Valves (where scheduled on drawings):

a) Control valves shall be pressure independent. The flow through the valve shall not vary more than +/- 5% due to system pressure fluctuations across the valve in the selected operating range. The control valve shall accurately control the flow from 1 to 100% full rated flow.
b) The valve bodies shall be of cast iron, steel or bronze and rated for 150 PSI working pressure. All internal parts shall be stainless steel, steel, Teflon, brass, or bonze.
c) DeltaP Valves manufactured by Flow Control Industries, Belimo P Series, Danfoss AB-QM Series, or approved equal.
d) The valves shall have pressure taps across the valve for measuring the pressure drop across the valve. The pressure taps shall have ½-inch extensions for accessibility.
e) Control valves shall be installed with unions or flanges as necessary for easy removal and replacement.
f) Valve Tag shall include the model number, AHU being served, design flow, and maximum flow for that valve.
g) The control valves shall be delivered preset to the scheduled design flow and should be capable of reaching 110% of the design flow to allow for field adjustment for capacity changes.

5. Automatic Balance Valves:

a. Valve body shall be constructed out of brass and rated for 400 PSIG working pressure.
b. Valve shall include an integrated chrome plated brass ball valve.
c. Valve body shall include two pressure\temperature ports.

d. Valve shall utilize a removable differential pressure regulating cartridge.
e. Removable differential pressure cartridge shall utilize a removable orifice plate to set the maximum flow through the valve.
f. Removable orifice plate shall be designed to maintain its size and shape while system is in operation. Additionally, the Cv through the orifice plate shall not change while the system is in operation.
g. Removable differential pressure cartridge shall feature a rolling EPDM rubber diaphragm to eliminate metal-on-metal contact and leak paths.
h. Valve body shall have the ability to accommodate a union ended tailpiece with SWTF, male NPT thread, female NPT thread connections and a union nut that can secure the tailpiece to the body of the valve to create a water-tight seal
i. Valve shall have maximum differential pressure limit of 60 psid.
j. Valve temperature range shall be from -4°F (-20°C) to 250°F (121°C).
k. Accessories: Extend pressure/temperature ports and Extended Handle
l. Bell & Gossett, Flow Design, Tour & Andersson or Griswold with removable/adjustable cartridge or approved equal.

D. Control Dampers: Ruskin CD-50 or approved equal.
1. Provide dampers with parallel blades for 2- position control.
2. Provide opposed blades for modulating control.
3. Dampers shall be low leakage design with blade and edge seals.
4. Provide multiple sections and operators as required by opening size and sequence of operations, as indicated on the contract drawings.

E. Electric Actuators: Johnson Controls, Bray, Belimo, TAC or approved equal. KMC actuators are not approved. Size electric actuators to operate their appropriate dampers or valves with sufficient reserve power to provide smooth modulating action or 2-position action as specified. If mixed air AHU has return air, exhaust air and outside air dampers that are not mechanically linked then static safety switch must be installed and wired to safety circuit. Spring return actuators should be provided on heat exchanger control valves or dampers or as specified on the drawings. Control signal shall be 0 to 10 VDC unless otherwise specified on drawings. Actuators with integral damper end switch are acceptable. For VAV reheat valves, actuators shall have a manual override capability to aid in system flushing, startup, and balancing.

F. Air and Hot Water Electronic Temperature Sensors:

1. All electronic temperature sensors shall be compatible with Johnson METASYS systems.
2. Sensors shall be 1,000 ohm platinum, resistance temperature detectors (RTDs) with two wire connections. Duct mounted sensors shall be averaging type. Contractor may install probe type when field conditions prohibit averaging type, but must receive permission from Owner's Representative.
3. Coordinate thermowell manufacturer with RTD manufacturer. Thermowells that are installed by the contractor, but are to have the RTD installed by owner, must be Johnson Controls Inc. series WZ-1000.

G. Electronic Temperature Sensors and Transmitters:
1. Chilled Water, Tower Water, Heating Hot Water, and Steam Temperature Sensors

a) General: The RTD/Temperature Transmitter/Thermowell assembly shall come as a complete assembly from a single manufacturer. The Assembly shall be suitable for use in the accurate measurement of Chilled/Tower/Hot Water and steam temperatures in a mechanical room environment.

b) Calibration: Each RTD must be match calibrated to the Transmitter via NIST traceable calibration standards. Results are to be programmed into the transmitter. Results are to be presented on report as after condition at the specified calibration points. Assembly shall not be approved for installation until Owner has received all factory calibration reports.

c) RTD:
   (1) RTD type: 2-wire or 3-wire 100 ohm platinum class A
   (2) Outside Diameter: 0.25 inch
   (3) Tolerance: +/- 0.06% Type A
   (4) Stability: +/- 0.1 % over one year.
   (5) TCR: 0.00385 (ohm/ohm/^{o}C).
   (6) RTD shall be tip sensitive.
   (7) Resistance vs. Temperature table for the RTD must be provided to the Owner.

d) Transmitter:
   (1) Transmitter shall be match calibrated to the RTD and assembled as a matched pair.
   (2) Type: 2 wire (loop powered)
   (3) Input: 2 or 3 wire 100 ohm platinum class A or class B RTD
   (4) Output: Output shall be a 4-20 mA signal linear to temperature
   (5) Calibrated Span:
      (a) Chilled Water: 30 ^{o}F to 130 ^{o}F.
      (b) Tower Water: 30 ^{o}F to 130 ^{o}F.
      (c) Hot Water: 100 ^{o}F to 250 ^{o}F.
      (d) Steam: 150 ^{o}F to 450 ^{o}F
   (6) Calibration Accuracy, including total of all errors, of the Transmitter & RTD matched pair over the entire span shall be within +/- 0.2% of the calibrated span or +/- 0.18 ^{o}F, whichever is greater.
   (7) Supply Voltage: 24 VDC.
   (8) Ambient Operating Temp.: 32 to 122 ^{o}F
   (9) Epoxy potted for moisture resistance.
   (10) Mounting: Transmitter shall be mounted in the RTD connection head.

e) Thermowell
   (1) Thermowell shall be suitable for immersion in chilled/hot water and steam.
   (2) Thermowell shall be reduced tip.
   (3) Thermowell shall be one piece stainless steel machined from solid bar stock.
   (4) Thermowell shall have 1/2” NPT process connection to pipe thred-o-let.
   (5) Thermowell Insertion depth shall be ½ the inside pipe diameter but not to exceed 10”.

f) Assembly:
   (1) Assembly configuration: Spring loaded RTD with thermowell-double ended hex-connection head.

(2) Connection head shall be cast aluminum with chain connecting cap to body, have 1/2" NPT process and 3/4" NPT conduit connections, and a sealing gasket between cap and body.

g) RTD/Temperature Transmitter/Thermowell assembly shall be the following or approved equal:
(1) Manufacturer: Pyromation, Inc.
(2) Chilled Water: RAF185L-S4C[length code]08-SL-8HN31,TT440-385U-S(30-130)F with calibration SMC(40,60)F
(3) Tower Water: RAF185L-S4C[length code]08-SL-8HN31,TT440-385U-S(5130)F with calibration SMC(55,85)F
(4) Hot Water: RAF185L-S4C[length code]08T2-SL-8HN31,TT440-385U-S(100-250)F with calibration SMC(140,180)F
(5) Steam: RAT185H-S4C[length code]08T2-SL-8HN31,TT440-385U-S(150-450)F with calibration SMC(300,350)F

H. Occupant Override: Provide wall mounted occupant override button in locations shown on drawings.

I. Low Limit Controllers: Provide unit-mounted low limit controllers, of rod-and-tube type, with an adjustable set point and a manual reset. Capillary shall be of adequate length to horizontally traverse face of cooling coil every 12". Multiple low limit controllers may be required for large coils. Controller shall have an extra set of contactors for connection to control panel for alarm status. Locate the thermostat case and bellows where the ambient temperature is always warmer than the set point.
1. Freeze Stats: Johnson Controls model A70HA-1 or approved equal.

J. Humidistats: Humidistats must be contamination resistant, capable of ±2% RH accuracy, have field adjustable calibration and provide a linear proportional signal.
1. HD20K-T91 or equivalent.

K. Humidity High Limit
1. Multi-function device that can function as a high limit or proportional override humidity controller, as stand-alone proportional controller, or a stand-alone two-position controller.
a) Johnson Controls TRUERH HL-67N5-8N00P or approved equal.

L. Carbon Dioxide Sensor:
1. Wall Mount: ACI Model ESENSE-R.
2. Duct Mount: ACI Model ESENSE-D.

M. Fan/Pump Status: Status points for fan or pump motors with a VFD must be connected to the terminal strip of the VFD for status indication.
Current switches: Current switches are required for fan and pump statuses that are not connected to a VFD. The switches must have an adjustable trip setpoint with LED indication and be capable of detecting broken belts or couplings. Units shall be powered by monitored line, UL listed and CE certified, and have a five year warranty.
1. Kele, Hawkeye or approved equal.

N. Relays Used for Fan and Pump Start/Stop: Must have LED indication and be mounted externally of starter enclosure or VFD.
   1. Kele, RIBU1C or approved equal.

O. Power Supply Used to Provide Power to Contractor-Provided Control Devices: Shall have adjustable DC output, screw terminals, overload protection and 24 VAC and 24 VDC output.
   1. Kele, DCPA-1.2 or approved equal.

P. Pressure Differential Switch:
   1. Fans: NECC model DP222 or approved equal.

Q. Differential Pressure Transmitter: Provide units with linear analog 4-20mA output proportional to differential pressure, compatible with the Johnson METASYS Systems.
   1. Water: Units shall be wet/wet differential pressure capable of a bi-directional pressure range of +/- 50 psid. Accuracy shall be +/- 0.25% full scale with a compensated temperature range of 30 to 150 deg F and a maximum working pressure of 250 psig.
   2. Install transmitter in a pre-manufactured assembly with shut off valves, vent valves and a bypass valve.
      a) Setra model 230 with Kele model 3-VLV, three valve manifold or approved equal.
   3. Air: Units shall be capable of measuring a differential pressure of 0 to 5 in. WC. Accuracy shall be +/- 1.0% full scale with a compensated temperature range of 40 to 149 deg F and a maximum working pressure of 250 psig.
      a) Setra model 267, or approved equal.
      b) Shall be installed in control panel and piped 2/3 down the duct unless shown otherwise or approved by owners representative.

R. Building Static Pressure: Transducer shall utilize a ceramic capacitive sensing element to provide a stable linear output over the specified range of building static pressure. Transducer shall be housed in a wall-mounted enclosure with LCD display. Transducer shall have the following capabilities:
   1. Input Power: 24 VAC
   2. Output: 0-10 VDC
   3. Pressure Range: -0.25 to +0.25 inches w.g.
   4. Display: 3-1/2 digit LCD, displaying pressure in inches w.g.
   5. Accuracy: +/- 1.0% combined linearity and hysteresis
   6. Temperature effect: 0.05% / deg C
   7. Zero drift (1 year): 2.0% max
   8. Zero adjust: Push-button auto-zero and digital input
   9. Operating Environment: 0 to 140 deg F, 90% RH (non-condensing)
   10. Fittings: Brass barbs, 1/8” O.D.
   11. Enclosure: High-impact ABS plastic
   12. Outside Air Sensor Pickup Port: UV stabilized thermoplastic or aluminum “can” enclosure to shield outdoor pressure sensing tube from wind effects. BAPI ZPS-ACC10-rooftop mount, wall mount, or equivalent.
   13. Transducer shall be Veris Industries Model PXPLX01S, equivalent from Setra, or approved equal.

S. High Static Pressure Limit Switch: Provide pressure high limit switch to open contact in fan circuit to shut down the supply fan when the inlet static pressure rises above the set point. Provide with an adjustable set point, a manual reset button, 2 SPST (normally closed) contacts, and ¼" compression fittings.
   1. Kele model AFS-460-DDS, or approved equal.

T. AIRFLOW/TEMPERATURE MEASUREMENT DEVICES
   1. Provide airflow/temperature measurement devices where indicated on the plans. Fan inlet measurement devices shall not be substituted for duct or plenum measurement devices indicated on the plans.
   2. The measurement device shall consist of one or more sensor probe assemblies and a single, remotely mounted, microprocessor-based transmitter. Each sensor probe assembly shall contain one or more independently wired sensor housings. The airflow and temperature readings calculated for each sensor housing shall be equally weighted and averaged by the transmitter prior to output. Pitot tubes and arrays are not acceptable. Vortex shedding flow meters are not acceptable.
   3. All Sensor Probe Assemblies
      a) Each sensor housing shall be manufactured of a U.L. listed engineered thermoplastic.
      b) Each sensor housing shall utilize two hermetically sealed, bead-in-glass thermistor probes to determine airflow rate and ambient temperature. Devices that use "chip" or diode case type thermistors are unacceptable. Devices that do not have 2 thermistors in each sensor housing are not acceptable.
      c) Each sensor housing shall be calibrated at a minimum of 16 airflow rates and have an accuracy of +/-2% of reading over the entire operating airflow range. Each sensor housing shall be calibrated to standards that are traceable to the National Institute of Standards and Technology (NIST).
         (1) Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.
      d) The operating temperature range for the sensor probe assembly shall be -20° F to 160 F. The operating humidity range for the sensor probe assembly shall be 0-99% RH (non-condensing).
      e) Each temperature sensor shall be calibrated at a minimum of 3 temperatures and have an accuracy of +/-0.15° F over the entire operating temperature range. Each temperature sensor shall be calibrated to standards that are traceable to the National Institute of Standards and Technology (NIST).
      f) Each sensor probe assembly shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. All terminal plug interconnecting pins shall be gold plated.
      g) Each sensor assembly shall not require matching to the transmitter in the field.
      h) A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter at a given measurement location.
   4. Duct and Plenum Sensor Probe Assemblies

a) Sensor housings shall be mounted in an extruded, gold anodized, 6063 aluminum tube probe assembly. Thermistor probes shall be mounted in sensor housings using a waterproof marine grade epoxy resin. All wires within the aluminum tube shall be Kynar coated.

b) The number of sensor housings provided for each location shall be as follows:

(1)

Area (sq.ft.)	Sensors
<2	4
2 to <4	6
4 to <8	8
8 to <16	12
>=16	16

c) Probe assembly mounting brackets shall be constructed of 304 stainless steel. Probe assemblies shall be mounted using one of the following options:
(1) Insertion mounted through the side or top of the duct.
(2) Internally mounted inside the duct or plenum.
(3) Standoff mounted inside the plenum.

d) The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

5. Fan Inlet Sensor Probe Assemblies
a) Sensor housings shall be mounted on 304 stainless steel blocks.
b) Mounting rods shall be field adjustable to fit the fan inlet and constructed of nickel plated steel.
c) Mounting feet shall be constructed of 304 stainless steel.
d) The operating airflow range shall be 0 to 10,000 FPM unless otherwise indicated on the plans.

6. Transmitters
a) The transmitter shall have a 16 character alpha-numeric display capable of displaying airflow, temperature, system status, configuration settings and diagnostics. Configuration settings and diagnostics shall be accessed through a pushbutton interface on the main circuit board. Airflow shall be field configurable to be displayed as a velocity or a volumetric rate.
b) The transmitter shall be capable of independently monitoring and averaging up to 16 individual airflow and temperature readings. The transmitter shall be capable of displaying the airflow and temperature readings of individual sensors on the LCD display.
c) The transmitter shall have a power switch and operate on 24 VAC (isolation not required). The transmitter shall use a switching power supply fused and protected from transients and power surges.
d) All interconnecting pins, headers and connections on the main circuit board, option cards and cable receptacles shall be gold plated.
e) The operating temperature range for the transmitter shall be -20° F to 120° F. The transmitter shall be protected from weather and water.
f) The transmitter shall be capable of communicating with the host controls using one of the following interface options:
(1) Linear analog output signal: Field selectable, fuse protected and isolated, 0-10VDC and 4-20mA (4-wire).
(2) RS-485: Field selectable BACnet-MS/TP, ModBus-RTU and Johnson Controls N2 Bus.

(3) 10 Base-T Ethernet: Field selectable BACnet Ethernet, BACnet-IP, ModBus-TCP and TCP/IP.
(4) LonWorks Free Topology.

g) The transmitter shall have an infra-red interface capable of downloading individual sensor airflow and temperature data or uploading transmitter configuration data to a handheld PDA (Palm or Microsoft Pocket PC operating systems).

7. The measuring device shall be UL listed as an entire assembly.
8. The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans. A written report shall be submitted to the consulting mechanical engineer if any measurement locations do not meet the manufacturer's placement requirements.
9. Manufacturer
   a) Primary flow elements, sensors, meters and transducers shall be EBTRON, Inc. Model GTx116-P and GTx116-F or approved equal.
   b) The naming of any manufacturer does not automatically constitute acceptance of this standard product nor waive their responsibility to comply totally with all requirements of the proceeding specification.

U. Electrical Requirements: Provide electric-pneumatic switches, electrical devices, and relays that are UL-listed and of type which meet current and voltage characteristics of the project. All devices shall be of industrial/ commercial grade or better. Residential types will be rejected.
   1. EP Switches: Landis & Gyr Powers, Inc. Series 265 - Junction Box Type or approved equal.
   2. Relays: Relays shall have an LED status indicator, voltage transient suppression, Closed-Open-Auto switch, plastic enclosure, and color coded wires. Kele model RIBU1C or approved equal.

V. Magnetic Flowmeter for Heating Water System:
   1. The Magnetic Flowmeter flow tube and computer/transducer shall come as a complete system assembled by a single manufacturer. The flowmeter shall be suitable for use in the accurate measurement of Heating Water flow for process control and/or utility metering, in a mechanical room environment, with a Johnson Controls EMCS system.
   2. The flowmeter shall consist of a pulsed DC electromagnetic coil incorporating Faraday's Law utilizing the flowing Water as the conductor. The flowmeter shall provide proper grounding for use in Schedule 40 steel pipe, Schedule 10S stainless steel pipe, or copper pipe as application requires.
   3. The flowmeter element should be sized to maintain maximum accuracy over the flow range of the application while keeping flow tube velocity below 15 fps at max flow. The flowmeter element shall be the flow tube, spool piece type with a non-conductive lining and no intrusions into the flow path. The flowmeter flow tube shall be suitable for direct mounting to standard ANSI flanges.
   4. The flowmeter shall have a local LCD display that indicates flow in GPM and/or Total gallons from the totalizer. The flowmeter shall be programmable/configurable via local push buttons. The flowmeter computer/transducer shall be remote mounted. The flow tube shall have a direct mounted junction box for wiring connections.
   5. The flowmeter shall have the capability to be calibrated insitu to verify proper operation and accuracies.

6. The flowmeter shall also meet the following specifications:

   a) Measures Bi-directional flow.
   b) Zero-point stability.
   c) Flow tube can withstand a full vacuum on an intermittent basis.
   d) Normal obstructions, partially opened valves, 90^0 or 45^0 elbows, and pump discharges shall require no more than 5 pipe diameters upstream and 3 pipe diameters downstream of straight pipe run for specified performance.
   e) Auto re-start after electrodes have lost wetness.
   f) Computer/transducers shall be interchangeable to multiple flow tubes without affecting the published accuracies of the meter.
   g) Computer/transducer internal electronic components, including power supply and output boards, shall be field interchangeable/exchangeable.
   h) Calibration: NIST Traceable, certificate provided with each meter.
   i) Electrode Pressure Rating: Equivalent to flow tube flange rating
   j) Minimum Conductivity: 5 mS/cm for fluid to be measured
   k) Transmitter Ambient Temp.: 122 ^{0}F
   l) Flow Tube Process Temp.: 32 ^{0}F to 140 ^{0}F for Chilled Water applications
   m) Flow Tube Process Temp.: 32 ^{0}F to 140 ^{0}F for Make Up Water applications
   n) Flow Tube Process Temp.: 32 ^{0}F to 311 ^{0}F for Hot or Dual Water applications
   o) Flow Range: +/- 0 to 30 fps
   p) Accuracy (velocity < /= 1.0 fps): +/- 0.5% of reading or +/- 0.005 fps
   q) Accuracy (velocity > 1.0 fps): +/- 0.5% of reading
   r) Analog Output: 4-20 mA, linear to flow in GPM
   s) Analog Output Accuracy: +/- 0.05% of span
   t) Repeatability: +/- 0.1%
   u) Stability: +/- 0.1%
   v) Ambient Temperature Effect: <1% per 100 ^{0}F
   w) Vibration Effect: 0.1% (remote mounted transducer)
   x) Low Flow Cutoff: settable to 0.04 fps or lower
   y) Low Flow Cutoff Analog Output: Analog output shall be 4.0 mA at flows below the low cutoff.
   z) Humidity Limits: 5-90% RH
   aa) Power Supply: 115 VAC
   bb) Power Consumption: 20 W maximum
   cc) Enclosures: NEMA 4
   dd) Flow Tube working pressure: 150 psi
   ee) Flanges: Carbon steel, ANSI Class 150#
   ff) Electrodes: Corrosion resistant Alloy C
   gg) Cable Length: As required per plans, 150 ft minimum
   hh) Cable shall be capable of empty pipe detection.
   ii) All cable shall be provided by the meter manufacturer.

7. The flowmeter shall be Foxboro IMT31A with 9500A, 9700A for high temperature, or approved equal.

8. Bids/Submittals: All bids and/or submittals must include published specifications, specific model number configurations, and operation & maintenance manuals.

9. Warranty: All parts and components as needed for the specified operation and performance shall be covered under warranty for a period of not less than two yearsrs.

3. EXECUTION

3.01 INSTALLATION OF CONTROL SYSTEMS

A. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings.

B. Control Air Piping:
1. All control air piping shall be copper. Exception: Flexible Tubing may be used for a maximum of two (2) feet at connections to equipment [except for steam control valves] and inside control cabinets.
2. Provide copper tubing with a maximum unsupported length of 3'-0".
3. Pressure Test control air piping at 30 psi for 24 hours. Test fails if more than 5 PSI loss occurs.
4. Fasten flexible connections bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support tubing neatly.
5. Number-code or color-code tubing, except local individual room control tubing, for future identification and servicing of control system.
6. All control tubing at control panel shall be tagged and labeled during installation to assist owner in making termination connections at control panel.
7. Provide pressure gages on each output device.
8. Paint all exposed control tubing to match existing.

C. Raceway: Raceway is to be installed in accordance with the National Electric Code. Use of flexible metal conduit or liquidtight flexible conduit is limited to 36" to connect from EMT to devices subject to movement. Flexible raceway is not to be used to compensate for misalignment of raceway during installation.

D. Control Wiring: Install control wiring in raceway, without splices between terminal points, color-coded. Install in a neat workmanlike manner, securely fastened. Install in accordance with National Electrical Code.
1. Install circuits over 25-volt with color-coded No. 12 stranded wire.
2. Install electronic circuits and circuits under 25-volts with color-coded No. 18 stranded twisted shielded pair type conductor.
3. N2 communications bus wire shall be 18 AWG, plenum rated, stranded twisted shielded, 3 conductor, with blue outer casing, descripted as 18-03 OAS STR PLNM NEON BLU JK distributed by Windy City Wire, constructed by Cable-Tek, or approved equivalent.

a) Metastat wiring shall be minimum 20 AWG, plenum rated, stranded, 8 conductor stranded wire.

4. FC communications bus wire shall be 22 AWG, plenum rated, stranded twisted shielded, 3 conductor, with blue outer casing, descripted as 22-03 OAS STR PLNM NEON BLU JK distributed by Windy City Wire, constructed by Cable-Tek, or approved equivalent.
   a) Network sensor wiring (SA Bus) shall be 22 gauge plenum rated stranded twisted wire, 4 conductor.
5. All control wiring at control panel shall be tagged and labeled during installation to assist owner in making termination connections at control panel. Label all control wires per bid documents.

E. All low voltage electrical wiring shall be run as follows:
   1. Route electrical wiring in concealed spaces and mechanical rooms whenever possible.
   2. Provide EMT conduit and fittings in mechanical rooms and where indicated on drawings.
   3. Low voltage electrical wiring routed above acoustical ceiling is not required to be in conduit, but wire must be plenum rated and properly supported to building structure.
   4. Provide surface raceway, fittings and boxes in finished areas where wiring cannot be run in concealed spaces. Route on ceiling or along walls as close to ceiling as possible. Run raceway parallel to walls. Diagonal runs are not permitted. Paint raceway and fittings to match existing conditions. Patch/repair/paint any exposed wall penetrations to match existing conditions.

F. All devices shall be mounted appropriately for the intended service and location.
   1. Adjustable thermostats shall be provided with base and covers in occupied areas and mounted 48" above finished floor to the top of the device. Tubing and/or wiring shall be concealed within the wall up to the ceiling where ever possible. Surface raceway may only be used with approval of Owners Representative. Wall mounted sensors such as CO2, RH, and non-adjustable temperature sensors shall be mounted 54” above finished floor. Duct mounted sensors shall be provided with mounting brackets to accommodate insulation. Mounting clips for capillary tubes for averaging sensors are required.
   2. All control devices shall be tagged and labeled for future identification and servicing of control system.
   3. Preheat and mixed air discharge sensors must be of adequate length and installed with capillary tube horizontally traversing face of coil, covering entire coil every 24 inches bottom to top.
   4. All field devices must be accessible or access panels must be installed.

G. Install magnehelic pressure gage across each air handling unit filter bank. If the air handling unit has a prefilter and a final filter, two magnehelic pressure gages are required.

3.02 ADJUSTING AND START-UP

A. Start-Up: Temporary control of Air Handling Units shall be allowed only if approved by the owner’s representative to protect finishes, etc., AHUs may be run using caution with temporary controls installed by contractor early in the startup process. All safeties including a smoke detector for shut down must be operational. Some means of discharge air control shall be utilized and provided by the contractor such as a temporary temperature sensor and controller located and installed by the Contractor.

B. The start-up, testing, and adjusting of pneumatic and digital control systems will be conducted by owner. Once all items are completed by the Contractor for each system, Contractor shall allow time in the construction schedule for owner to complete commissioning of controls before project substantial completion. This task should be included in the original schedule and updated to include the allotted time necessary to complete it. As a minimum, the following items are required to be completed by the Contractor for Owner to begin controls commissioning.
   1. Process Control Network
      a) The control boards and enclosures need to be installed in the mechanical rooms.
      b) The fiber optic conduit and box for the process control network needs to be installed. Once in place, Owner needs to be contacted so the length of the owner provided fiber cable can be determined and ordered, if required. Coordinate with Owner to schedule the pull in and termination of the fiber cable. Power should be in place at that time. (Fiber for the process control network is required to allow metering of utilities prior to turn on.)
   2. Heating System
      a) Pumps, heat exchangers, steam pressure reducing station, piping, control valves, steam and/or hot water meter, feeder conduit and wire, VFDs, control panels and control wiring installed in the mechanical room. The house keeping pads must be poured before pump operation. All must be in place in working order (pumps aligned, VFDs set up by vendor, motors checked for rotation, steam regulators set to required pressure, condensate pumps operational, heating system ready to circulate (all piping pressure tested, flushed, and insulated) with differential pressure sensors in place.
   3. Cooling System
      a) Pumps, heat exchangers, piping, control valves, chilled water meter, feeder conduit and wire, VFDs, control panels and control wiring installed in the mechanical room. The house keeping pads must be poured before pump operation. All must be in place in working order (pumps aligned, VFDs set up by vendor, motors checked for rotation, cooling system ready to circulate (all piping pressure tested, flushed, and insulated) with differential pressure sensors in place.
   4. VAVs-First Pass
      a) Power, (FC or N2 bus), and control wire installed before owner can make first commissioning pass. First pass includes installation of VAV controller, termination of power, control and network communication wiring.
   5. Air Handlers
      a) Prior to owner commissioning, at a minimum, the following items shall be complete: Power wiring, motor rotation check, fire/smoke dampers open, control wiring including all safeties, IO cabinet, air handler cleaned, and filters installed as required. To protect the systems from dirt, outside air with no return will be used until the building is clean enough for return air operation.
   6. VAVs-Second Pass
      a) After the air handlers are running and under static pressure control and the heating water system is operating, a second pass can be made on the VAVs to download the control program and commission controllers to verify the VAV dampers, thermostat, and reheat control valves are working properly.
   7. Exhaust and Energy Recovery Systems

a) Exhaust fans need to be operational and under control before labs can be commissioned.

8. Lab Air Controls
   a) Lab Air Controls vendor will have the same requirements as stated above for VAVs.
9. Some balance work can be done alongside the control work as long as areas are mostly complete and all diffusers are in place.

3.03 CLOSEOUT PROCEDURES

A. Contractor shall provide complete diagrams of the control system including flow diagrams with each control device labeled, a diagram showing the termination connections, and an explanation of the control sequence. The diagram and sequence shall be framed and protected by glass and mounted next to controller.
B. Contractor shall provide as built diagram of network bus routing listing all devices on bus, once wiring is complete prior to scope completion.

END OF SECTION

SECTION 23 09 93
SEQUENCE OF OPERATION

1. GENERAL

1.1 The sequences provided in this section are subject to minor modifications during shop drawing review phase and system start-up. These minor changes are usually due to the specific operating characteristics of the HVAC equipment actually installed and/or building dynamics. These minor sequence modifications shall be incorporated without additional charges to the Owner.

1.2 All control set points called out shall be adjustable through software.

1.3 Refer to drawings for sequences of operation.

END OF SECTION

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SECTION 23 21 13
HYDRONIC PIPING

1. GENERAL

1.1 SECTION INCLUDES

A. Above grade pipe, fittings, and joints for:

1. Heating water piping system.
2. Equipment drains and overflows.
3. Steam piping to humidifier dispersion grid

B. Valves.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

B. References.

C. Submittals.

D. Operation and maintenance manuals.

E. Project record documents.

1. Record actual locations of valves.

F. Delivery, storage, and handling.

1.3 SYSTEM DESCRIPTION

A. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

B. Grooved mechanical couplings and fasteners may be used in mechanical rooms.

C. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.

D. Where connecting ferrous and non-ferrous piping materials, use full-port ball valves with bronze construction or a galvanized steel dielectric nipples with plastic liner to separate piping materials.

E. Use gate, ball or butterfly valves for shut-off and to isolate equipment, part of systems, or vertical risers or as shown on plans.

F. Use ball or butterfly valves for throttling, bypass, or manual flow control services or as shown on plans.

G. Use lug end butterfly valves to isolate equipment.

1.4 REGULATORY REQUIREMENTS

A. Conform to International Mechanical Code for installation of piping system.

B. Welding Materials and Procedures: Conform to ASME SEC 9 and applicable state and local labor regulations.

C. Provide certificate of compliance from authority having jurisdiction indicating approval of welders.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Do not install underground piping when bedding is wet or frozen.

1.6 EXTRA MATERIALS

A. Provide two repacking kits for each size and valve type.

2. PRODUCTS

2.1 STEEL PIPING, FITTINGS, AND JOINTS

A. Applicable Systems

1. Heating water

B. Pipe: ASTM A53, Schedule 40, Grade B, black steel.

C. Fittings (2" and smaller): Malleable Iron: ASTM B16.3, Class 150, threaded or Cast Iron: ASTM B16.4, Class 125, threaded.

D. Fittings (2-1/2" and larger): ASTM B16.9, steel butt weld fittings.

E. Joints (2" and smaller): Threaded.

F. Joints (2-1/2" and larger): AWS D1.1, welded.

G. Unions (2" and smaller): 150 psig malleable iron, threaded.

H. Flanges (2-1/2" and larger): 150 psig forged steel, slip-on type.

1. Gaskets: Flexitallic Style CG semi-metallic spiral wound gaskets, no equivalent.

a. Filler material shall be Flexicarb (Graphite) SEL with max temperature rating of 842 deg F.
b. Gasket thickness:

1) 0.0625" for pipe sizes with maximum inside dimension up to 6".
2) 0.100" for pipe sizes with maximum inside dimensions between 6" and 10".

2. Flanges shall be flat face when mating with 125# class cast iron valves.

I. Grooved Mechanical Fittings:

1. Ductile Iron: ASTM A 536, Grade 65-45-12
2. Malleable Iron: ASTM A 47/A 47M, Grade 32510
3. Steel: ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
4. Standard of acceptance: Victaulic Style 107N Rigid Coupling.

J. Grooved Pipe End Couplings:

1. Housing Clamps: Malleable iron or ductile iron to engage and lock, designed to permit some angular deflection, contraction, and expansion.
2. Sealing Gasket: C-shape elastomer composition for operating temperature range from -30 degrees F to 230 degrees F.

3. Accessories: Steel bolts, nuts, and washers.

2.2 COPPER TUBING, FITTINGS, AND JOINTS

A. Applicable Systems

1. Heating water
2. Equipment drains and overflows

B. Pipe: ASTM B88, Type L, hard drawn (2" and smaller)

C. Fittings and Unions (2" and smaller): ASME B16.22 wrought copper and bronze:

1. Solder filler metals: ASTM B32, lead-free alloys.
2. Flux: ASTM B813, water-flushable.
3. Copper Pressure-Seal-Joint Fittings
   a. Viega, Mueller or approved equivalent
   b. Fittings for pipes 2" and smaller: Wrought-copper fittings with EPDM-rubber, O-ring seal in each end.

D. Flanges (2-1/2" and larger): Bronze, 1/16 inch thick preformed neoprene gaskets.

E. STAINLESS STEEL PIPING, FITTINGS, AND JOINTS (PIPE SIZES LARGER THAN 2")

1. Applicable Systems

   a. Steam humidifier piping between boiler and dispersion grid.

2. Schedule 40 stainless steel pipe; same type stainless steel flanges and wrought stainless steel flanged fittings.
3. Schedule 40 stainless
4. Pipe to be slope per manufacturer's recommendations.
5. Provide drains per manufacturer's recommendations.

2.3 DIELECTRIC NIPPLE

A. Electroplated steel nipple, complying with ASTM F 1545 and IAPMO PS 66.

1. Rated for 300 psig at 225 deg F.
2. Male threaded or grooved end connections.
3. Inert and noncorrosive propylene lining.
4. Use a dielectric waterway equal to Victaulic or Clearflow

2.4 VALVES

A. CALIBRATED BALANCE VALVES

1. Pre-Set Balance Feature. Valves to be designed to allow Installing Contractor to pre-set balance points for proportional system balance prior to system start-up in accordance with scheduled flow rates.
2. Valve Design and Construction. All valves shall have a calibrated orifice or venturi section, two ¼" threaded pressure tap ports with integral seals, and memory stop to retain the set position. Valves should be rated for 125 psig working pressure and 250 Deg. F maximum operating temperature.
3. Valves shall be selected based on flowrate, not on pipe size dimensions.
4. Preformed Insulation. All valves to be provided with molded insulation to permit access for balance and read-out.
5. Bell and Gossett CBV, Tour & Andersson or Armstrong – Flow Setter ΔP type or equivalent

B. BALL VALVES

1. Up To and Including 2 Inches:

    a. Bronze two piece body, stainless steel full-port ball on all systems, Teflon seats and stuffing box ring, lever handle with balancing stops, solder or threaded ends. Include stem extensions on valves used in insulated piping systems. Victaulic 722, Nibco, or equal.
    b. Press connection with EPDM sealing element, brass / bronze, full port, non-potable application. Viega 2973, or equal.

C. BUTTERFLY VALVES

1. 2-1/2 Inches and Larger:

    a. Body: Cast or ductile iron with resilient replaceable EPDM seat, lug ends, extended neck.
    b. Disc: Aluminum bronze on closed systems and stainless steel on open systems.
    c. Stem: Stainless steel, extended on insulated systems as required to allow valve operation without damage to the insulation.
    d. Operator (4" and smaller): 10 position lever handle with memory stop, gear drive.
    e. Operator (6" and larger): Handwheel, gear drive.
    f. Chainwheel: On valves 6" and larger and installed higher than 8-feet above finished floor, provide sprocket rim, brackets, and chain compatible with valve.
    g. Grinnel or equal.

h. Grooved: Cast ductile iron, grooved ends, EPDM seat, off-set electroless-nickle fusion bonded DI disc, 300 PSI bubble tight dead-end service, 316SS stem, Victaulic Series 761 / W761 or equal.

D. SWING CHECK VALVES

1. Up To and Including 2 Inches:

a. Bronze body, bronze trim, bronze rotating swing disc, with composition disc, solder or threaded ends. Nibco or equal.

2. Over 2 Inches:

a. Flanged, cast iron, 125 lb., bolted bonnet, horizontal swing, bronze trim. Nibco or equal.
b. Grooved, cast ductile iron, 300 PSI, horizontal or vertical swing, brass / SS trim. Victaulic Series 716 / W716 / 779 or equal.

E. SPRING LOADED CHECK VALVES

1. Iron body, bronze trim, split plate, hinged with stainless steel spring, resilient seal bonded to body, wafer or threaded lug ends.

3. EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

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

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

D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

3.2 INSTALLATION

A. Grooved pipe fittings and joints may only be used in accessible locations.

B. Where connecting ferrous and non-ferrous piping materials, use full-port ball valves with bronze construction or a galvanized steel dielectric nipples with plastic liner to separate piping materials.

C. Heating water connections to terminal units shall be copper (no steel).

D. Install all piping in accordance with ASME B31.9.

E. Route piping in orderly manner, parallel to building structure, and maintain gradient.

F. Install piping to conserve building space, and not interfere with use of space.

G. Group piping whenever practical at common elevations.

H. Sleeve pipe passing through partitions, walls and floors.

I. Slope piping and arrange to drain at low points.

J. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

K. Refer to Section 23 05 29 and Section 23 05 48 for installation of supports and hangers.

L. Provide insulation clearance and access to valves and fittings in hangers and from structure and other equipment. Insulation shall be continuous through all hangers and supports. Refer to Section 23 07 19.

M. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with General Contractor and requirements of Section 23 05 00.

N. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.

O. Install unions on both sides of each control valve and on one side of all other valves. Install unions on the equipment side of final connections to each piece of equipment. Unions are not required at flanged valves or equipment.

P. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.

Q. Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting.

R. Install valves with stems upright or horizontal, not inverted.

S. Provide insulated valve stem extensions on all valves installed in insulated piping systems.

T. Install chainwheel operators on valves 6" and larger that are installed 8-feet above finished floor or greater. Extend chain down to maximum 5-feet above finished floor.

U. Where possible, pipe connections shall be installed with the branch piping connected to the top of the main/header. If this is not possible due to space constraints, a connection with the same vertical centerline is acceptable. Connections to the bottom of the main/header is not allowed.

V. Provide solid chrome plated steel escutcheons cover the sleeves and openings at walls and ceilings in exposed areas.

3.3 SYSTEM FLUSHING, FILLING, PRESSURE TESTING AND CLEANING

A. Flush, fill, pressure test and clean all new hydronic systems and parts of existing systems which have been altered, extended or repaired.

B. Flush and fill systems with all valves open to coils. Bleed air from coils and piping. Clean strainers.

C. Pressure Test Procedure:

1. Reference Section 23 05 00 for minimum test pressures.
2. Submit copy of Pipe Pressure Test Log provided in section 23 05 00 for each section of piping tested. Refer to 23 05 00 for general pipe pressure testing requirements (i.e., test pressure gages, inspections, etc.).
3. Leave joints including welds uninsulated and exposed for examination during the test.
4. Provide temporary restraints for expansion joints which cannot sustain the reactions due to test pressure. If temporary restraints are not practical, isolate expansion joints from testing.
5. Isolate equipment that is not to be subjected to the test pressure from the piping. If a valve is used to isolate the equipment, its closure shall be capable of sealing against the test pressure without damage to the valve. Flanged joints at which blinds are inserted to isolate equipment need not be tested.
6. Install relief valve set at a pressure no more than 1/3 higher than the test pressure, to protect against damage by expansion of liquid or other source of overpressure during the test.
7. Subject piping system to a hydrostatic test pressure which at every point in the system is not less than 1.5 times the design pressure. The test pressure shall not exceed the maximum pressure for any vessel, pump, valve, or other component in the system under test.
8. After the hydrostatic test pressure has been applied for at least 12 hours, examine piping,

joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components as appropriate, and repeat hydrostatic test until there are no leaks.

D. Clean systems.

END OF SECTION

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SECTION 23 21 16
HYDRONIC SPECIALTIES

1. GENERAL

1.1 SECTION INCLUDES

A. Expansion tanks.

B. Air vents.

C. Air/Dirt separators.

D. Strainers.

E. Relief valves.

F. Flexible connections.

G. Chemical pot feeders.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. References.

B. Submittals.

C. Project record documents

1. Record actual locations of hydronic specialties.

D. OPERATION AND MAINTENANCE DATA

1. Furnish service and maintenance of glycol system for one year from date of substantial completion.
2. Monthly visit to make glycol fluid concentration analysis on site with refractive index measurement instrument. Detail findings with maintenance personnel in writing of corrective actions needed including analysis and amounts of glycol or water added.
3. Provide full laboratory analysis of fluid at 6 months and 12 months from the date of substantial completion.

E. QUALIFICATIONS

F. DELIVERY, STORAGE AND HANDLING

2. PRODUCTS

2.1 EXPANSION TANKS

A. Construction: Welded steel, tested and stamped in accordance with ASME SEC VIII, Division 1; supplied with National Board Form U 1, rated for working pressure of 125 psig, with flexible, replaceable, butyl rubber bladder sealed into tank and steel support stand.

B. Accessories: Pressure gauge and air-charging fitting, tank drain.

2.2 AIR VENTS

A. Manual Type: Short vertical sections of equal diameter pipe, up to 2", to form air chamber, with ball valve, hose connection, and cap.

2.3 AIR/DIRT SEPARATORS

A. Air/Dirt Separators:

1. Steel construction, rated for 150 psig, and entering velocity not to exceed 10 feet per second at specified water flow rate.
2. Unit shall be capable of removing 100% of the free air, 100% of the entrained air, and up to 99.6% of the dissolved air in the system.
3. Dirt separation shall be at least 80% of all particles 30 micron or larger within 100 passes.
4. Internal bundle filling the entire vessel consisting of a copper core tube with continuous wound copper medium permanently affixed to the core. A separate copper medium is to be wound completely around and permanently affixed to the internal element. Each eliminator shall have a separate venting chamber to prevent system contaminants from harming the float and venting valve operation. At the top of the venting chamber shall be an integral full port float actuated brass venting mechanism. Units shall include a valved side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill. Separator shall have the vessel extended below the pipe connections an equal distance for dirt separation. Bottom connection for use as a blowdown.
5. Integral mounting lugs on large units (14" and larger) for use with contractor-provided mounting legs.
6. Unit shall be manufactured with internal magnet(s), if so noted on the drawings and schedule.

    a. Magnet(s) shall be positioned at the centerline of the inlet and outlet nozzles for maximum effectiveness during normal operation.

1) Units sized 2” through 6” shall have one magnet
2) Units with 8” though 12” shall have two magnets

b. Magnet(s) shall be removable from the vessel.
c. Magnet(s) shall be made of high-strength Neodymium alloy.
d. Magnet(s) shall be disengaged for dirt blowdown by means of a spring-loaded pull, without requiring removal of the magnet from the vessel or isolating the unit from the system.
e. Magnet option shall be provided with 360° rotatable blow down valve.

7. Manufacturer:

a. Heating Water: Spirotherm or approved equal

2.4 STRAINERS

A. Size 2 inch and Under:

1. Screwed brass or iron body for 175 psig working pressure, Y pattern with 1/32 inch Type 304 stainless steel perforated screen.

B. Size 2-1/2 inch to 4 inch:

1. Flanged iron body for 175 psig working pressure, Y pattern with 3/64 inch Type 304 stainless steel perforated screen.

C. Size 5 inch and Larger:

1. Flanged iron body for 175 psig working pressure, basket pattern with 1/8 inch Type 304 stainless steel perforated screen.

D. Provide blowdown valves where shown on plan.

2.5 SAFETY RELIEF VALVES

A. Cast iron or Bronze body, EPDM seat, brass internal parts, automatic, direct pressure actuated, capacities ASME certified and labeled.

2.6 FLEXIBLE CONNECTIONS

A. Stainless steel braided connection with steel flange rated for 225 psig and 16" Hg vacuum. Operating temperature 20 degrees F. to 240 degrees F.

B. Minimum allowable movement shall be as follows:

Lateral Deflection	1/2"
Elongation	3/8"
Compression	1/2"
Angular Deflection	15 degrees

2.7 CHEMICAL POT FEEDERS

A. Manufacturer:

1. Neptune model DBF-5HP or equivalent.

B. Bypass feeder, vertical style, dish bottom out.

C. 4” high pressure fill cap rated to 300 psig, 2-1/2 turn design w/ coars thread.

D. Demountable leg extensions.

E. Filter bag kit.

3. EXECUTION

3.1 INSTALLATION

A. Install specialties in accordance with manufacturer's instructions and as shown on drawings.

B. Provide manual air vents at all system high points and in accessible locations.

C. Provide drain valves at all low points and in accessible locations.

D. Provide heat trap piping arrangement for all expansion tanks as shown on drawings or per manufacturer instructions.

E. Provide appropriately sized structural supports for air/dirt separators. Support air/dirt separator independently of piping system for larger sizes per manufacturer’s instruction.

F. Provide valved drain and hose connection on strainer blow down connection.

G. Provide flexible connectors on pump suction and discharge.

H. Provide flexible connectors on all pipe connections that serve vibration isolated mechanical equipment.

I. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

END OF SECTION

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SECTION 23 21 23
HVAC Pumps

1. GENERAL

1.1 SECTION INCLUDES

A. Base-mounted, end-suction centrifugal pumps.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. References.

1. HI - Hydraulic Institute.
2. ANSI - American National Standards Institute.
3. OSHA - Occupational Safety & Health Administration.
4. ASHRAE – American Society of Heating, Refrigeration and Air-Conditioning Engineers.
5. NEMA - National Electrical Manufacturers Association.
6. UL - Underwriters Laboratories.
7. ETL - Electrical Testing Laboratories.
8. CSA - Canadian Standards Association.
9. NEC - National Electric Codes.
10. ISO - International Standards Organization.
11. IEC - International Electrotechnical Commission.
12. ASME – American Society of Mechanical Engineers.

B. Performance requirements.

1. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within ± 10 percent of scheduled performance and published operating curve.

C. Submittals.

1. Submit each item in this article according to the Conditions of the Contract and Division 1 Specification Sections.
2. Submit manufacturer's installation instructions under provisions of General Conditions and Division 1.

    a. Operation and Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts lists.

b. Under provisions of commissioning documentation, testing of pumps, as well as training of owner's operation and maintenance personnel may be required in cooperation with the commissioning consultant.

3. Product Data including certified performance curves and rated capacities of selected model, weights (shipping, installed, and operating), furnished specialties, and accessories. Indicate pump's operating point on curves.
4. Complete Package information Product Data including:

   a. System summary sheet (where applicable)
   b. Sequence of Operation
   c. Shop drawing indicating dimensions, required clearances and location and size of each field connection
   d. Power and control wiring diagram
   e. System profile analysis including pump curves, system curve, and variable speed pump curves (where applicable)
   f. Pump data sheets - Rated capacities of selected models and indication of pump's operating point on curves.
   g. Submittals on furnished specialties and accessories
   h. Submittals must be specific to this project. Generic submittals will not be accepted

5. A detailed weighted average pump efficiency-Part Load Efficiency Value (PLEV) - Pump Rating Report shall be submitted for each pump. Pump PLEV shall be based on the standard load profile developed in AHRI 550/590-1998 also known as IPLV or Integrated Part Load Value. The pump PLEV Rating shall be expressed with load weighting pump PLEV=1/ (0.01/A+0.42/B+0.45/C+0.12/D) & shall be based points on A: 100%, B: 75%, C: 50% and D: 25%. Each Pump Efficiency ratings shown with flow matched to load percentage and Specified Control Head. Actual job specific load profile weighting may be substituted for standard IPLV weighting.
6. Pump and motor must meet minimum Department of Energy requirements and have a PEICL value less than 1
7. Specified Control Head shall be 30% TDH or calculated minimum control head specified within the equipment schedule
8. Hanging and supporting requirements should follow the recommendations in the manufacturer's installation instructions
9. Submittals that are "rejected" as being "non-compliant" will be re-reviewed once with all time for subsequent reviews back charged to the contractor in accordance with the engineer's current prevailing rate schedule. If a rate schedule for additional services is included, as part of the contract with the owner that rate schedule shall be used in lieu of the "current prevailing" rate schedule.

D. Quality Assurance

1. All equipment or components of this specification section shall meet or exceed the requirements and quality of the items herein specified, or as denoted on the drawings.

2. Ensure pump operation at specified system fluid temperatures without vapor binding and cavitation, is non-overloading in parallel or individual operation, and operates to ANSI/HI 9.6.3.1 standard for Preferred Operating Region (POR) unless otherwise approved by the engineer.
3. Ensure pump pressure ratings are at least equal to system's maximum operating pressure at point where installed but not less than specified.
4. Equipment manufacturer shall be a company specializing in manufacture, assembly, and field performance of provided equipment with a minimum of 20 years experience.
5. Equipment provider shall be responsible for providing certified equipment start-up and, when noted, an in the field certified training session. New pump start-up shall be for the purpose of determining pump alignment, lubrication, voltage, and amperage readings. All proper electrical connections, pump's balance, discharge and suction gauge readings, and adjustment of head, if required. A copy of the start-up report shall be made and sent to both the contractor and to the Engineer.

E. Operation and maintenance data.

F. Qualifications.

G. Delivery, storage and handling.

1. Deliver materials to the site in such a matter as to protect the materials from shipping and handling damage. Provide materials on factory provided shipping skids and lifting lugs if required for handling. Materials damaged by the elements should be packaged in such a matter that they could withstand short-term exposure to the elements during transportation.
2. Store materials in clean, dry place and protect from weather and construction traffic. Handle carefully to avoid damage.
3. Use all means necessary to protect equipment before, during, and after installation.
4. All scratched, dented, and otherwise damaged units shall be repaired or replaced as directed by the Architect Engineer.

H. Warranty

1. Provide a minimum One (1) year warranty on materials and installation under provision of Division 1.

I. Extra materials.

1. Provide one set of mechanical seals and gaskets for each pump.

2. PRODUCTS

2.1 BASE MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturer: Subject to compliance with requirements, provide comparable product by one of the following:

1. Bell and Gossett Series 1510
2. Armstrong Pumps, Inc.
3. Or approved equivalent.

B. See pump schedule on drawings for performance requirements.

1. The pumps shall be long coupled, base mounted, single stage, end suction, vertical split case design, in cast iron stainless steel fitted, specifically designed for quiet operation. Suitable standard operations at 225°F and 175 PSIG working pressure or optional operations at up to 250°F and 250 PSIG working pressures. Working pressures shall not be de-rated at temperatures up to 250F. The pump internals shall be capable of being services without disturbing piping connections, electrical motor connections or pump to motor alignment.
2. The pumps shall be composed of three separable components a motor, bearing assembly, and pump end (wet end). The motor shaft shall be connected to the pump shaft via a replaceable flexible coupling.
3. A bearing assembly shall support the shaft via two heavy-duty regreaseable ball bearings. Bearing assembly shall be replaceable without disturbing the system piping and shall have foot support at the coupling end. Pump bearings shall be regreaseable without removal of the bearings from the bearing assembly. Thermal expansion of the shaft toward the impeller shall be prevented via an inboard thrust bearing.
4. The bearing assembly shall have a solid SAE1144 steel shaft. A stainless steel shaft sleeve shall be employed to completely cover the wetted area under the seal.
5. Pump shall be equipped with an internally-flushed mechanical seal assembly installed in an enlarged tapered seal chamber. Application of an internally flushed mechanical seal shall be adequate for seal flushing without requiring external flushing lines. Seal assembly shall have Buna bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.
6. Bearing assembly shaft shall connect to a stainless steel impeller. Impeller shall be both hydraulically and dynamically balanced to ANSI/HI 9.6.4-2016, balance grade G6.3 and secured by a stainless steel locking cap screw or nut.
7. Pump should be designed to allow for true back pull-out allowing access to the pump's working components, without disturbing motor or piping, for ease of maintenance.
8. A center drop-out type coupling, capable of absorbing torsional vibration, shall be employed between the pump and motor. Pumps for variable speed application shall be provided with a suitable coupling sleeve. Coupling shall allow for removal of pump's wetted end without disturbing pump volute or movement of the pump's motor and electrical connections. On variable speed applications the coupling sleeve should be constructed of an neoprene material to maximize performance life.
9. An ANSI and OSHA rated coupling guard shall shield the coupling during operation. Coupling guard shall be dual rated ANSI B15.1 and OSHA 1910.219 compliant coupling guard and contain viewing windows for inspection of the coupling. No more than .25 inches of either rotating assembly shall be visible beyond the coupling guard.

10. Pump volute shall be of a cast iron design for heating systems with integrally cast pedestal volute support, rated for 175 PSIG with integral cast iron flanges drilled for 125# ANSI companion flanges. (Optional 250 PSIG working pressures are available and are 250# flange drilled.) Volute shall include gauge ports at nozzles, and vent and drain ports.
11. Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Pump and motors shall be factory aligned, and shall be realigned after installation by the manufacturer's representative. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications and conform to standards outlined in EISA 2007.
12. Base plate shall be of structural steel or fabricated steel channel configuration fully enclosed at sides and ends, with securely welded cross members and fully open grouting area (for field grouting). The minimum base plate stiffness shall conform to ANSI/HI 1.3.8.2.1-2019 for grouted Horizontal Baseplate Design standards.
13. Pump shall be of a maintainable design and, for ease of maintenance, should use machine fit parts and not press fit components.
14. The pump(s) vibration limits shall conform to Hydraulic Institute ANSI/HI 9.6.4-2016 for recommended acceptable unfiltered field vibration limits (as measured per ANSI/HI 9.6.4-2016 Figure 9.6.4.2.3.1) for pumps with rolling contact bearings.
15. Pump manufacturer shall be ISO-9001 certified.
16. Each pump shall be hydrostatically tested 1.5 times the maximum rated working pressure and name-plated before shipment.
17. Pump shall conform to ANSI/HI 9.6.3.1-2012 standard for Preferred Operating Region (POR) unless otherwise approved by the engineer.

C. Accessories:

1. Provide one mechanical seal for each model type of primary pump based on scheduled operating temperature.
2. Prov with internal volute wear rings, galvanized drip pan, or special spacer couplings.
3. Where noted on schedule a stuffing box design may be used in lieu of the traditional internally flushed mechanical seal design. Pump shall be flushed single seal or packing gland type seal arrangements.

2.2 PUMP SPECIALTY FITTINGS

A. Suction Diffuser

1. Manufacturer: Subject to compliance with requirements, provide comparable product by one of the following:

   a. ITT Corporation
   b. Taco Comfort Solutions, Inc.
   c. Armstrong Pumps, Inc.
   d. Grundfos Pumps Corporation
   e. Or equivalent.

2. Angle pattern.
3. 175 psig pressure rating, cast-iron body and end cap, pump-inlet fitting.
4. Cylinder stainless steel strainer with 3/16 inch diameter openings, disposable fine mesh strainer to fit over cylinder strainer, and permanent magnet located in flow stream and removable for cleaning Bronze or stainless-steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.
7. Blowdown tap
8. Gage tap

3. EXECUTION

3.1 PREPARATION

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

3.2 INSTALLATION

A. All components shall be installed in accordance with manufacturer's installation instructions.

B. Reduction from line size to pump connection size shall be made with eccentric reducers attached to the pump with tops flat to allow continuity of flow.

C. Furnish and install check valve, isolation valve and balance valve on the discharge side of all pumps and furnish and install a line size shut-off valve on the suction side of all pumps. Furnish and installed suction diffuser on the inlet side of a pump to provide appropriate flow distribution into the eye of the pump's impeller.

D. Provide temperature and pressure gauges where and as detailed or directed.

E. Proper access space around a device should be left for servicing the component. No less than the minimum recommended by the manufacturer.

F. Provide an adequate number of isolation valves for service and maintenance of the system and its components.

G. Circulating pump shall have sufficient capacity to circulate the scheduled GPM against the scheduled external head (feet) with the horsepower and speed as scheduled and/or as denoted on the drawings. Motors shall be of electrical characteristics as scheduled, denoted and/or as indicated on the electrical plans and specifications. Pump characteristics shall be such that the head of the pump under varying conditions shall not exceed the rated horsepower of the drive motor.

H. On systems where the final balancing procedure requires the balancing valve to be throttled more than 25% to attain design flow (on a constant speed pumping system), and no future capacity has been built into the pump, the pump impeller must be trimmed to represent actual system head resistance. The pump provider and engineer of record, based on the balancing contractor's reports, shall determine the final impeller trim diameter.

I. Install foot mounted and base mounted pumps on vibration isolation pad and house keeping pad, via anchor bolts. Set and level and grout in place.

J. All piping shall be brought to equipment and pump connections in such a manner so as to prevent the possibility of any loads or stresses being applied to the connections or piping. All piping shall be fitted to the pumps even though piping adjustments may be required after the pipe is installed.

K. On components that require draining, contractor must provide piping to and discharging into appropriate drains.

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

M. Power wiring, as required, shall be the responsibility of the electrical contractor. All wiring shall be performed per manufacturer's instruction and applicable state, federal, and local codes.

N. Control wiring for remote mounted switches and sensor / transmitters shall be the responsibility of the control's contractor. All wiring shall be performed per manufacturer's instructions and applicable state, federal, and local codes.

3.3 START-UP AND COMMISSIONING

A. Start-up pump in accordance to manufacturer written instructions.

B. Before and after start-up, perform the following preventative maintenance operations and checks:

1. Lubricate bearings.
2. Check, align and certify alignment of base mounted pumps prior to start-up. Pump alignment shall be certified by 3rd party testing agency using laser alignment procedures.
3. After pump is started, check for proper rotation, proper mechanical operation and motor load to ensure that pump is not overloaded. Close pump balancing valve as required to bring pump motor load within motor nameplate data.
4. Check pumps to ensure it is not air bound or cavitating.
5. After sufficient run time, remove, check and clean strainer as required. Repeat cleaning strainer until system is sufficiently flushed. Refer to Section 23 25 00, Chemical Water Treatment.
6. After completing start-up, replace pump strainer with permanent strainer.

C. Coordinate pump testing, adjusting and balancing with Balancing Contractor. Complete additional preliminary work required by Balancing Contractor.

END OF SECTION

SECTION 23 31 13
DUCTWORK

1. GENERAL

1.1 SECTION INCLUDES

A. Metal ductwork.

1. Sheet metal materials.
2. Sealant and gaskets.
3. Fasteners.
4. Seismic-restraint devices.
5. Duct cleaning.
6. Duct pressure testing.

B. Insulated flexible ductwork.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

1. Perform Work in accordance with the following standards:

a. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
b. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems.
c. SMACNA - HVAC Air Duct Leakage Test Manual.
d. SMACNA – HVAC Duct Construction Standards - Metal and Flexible.
e. SMACNA - Round Industrial Duct Construction Standards
f. International Mechanical Code, current edition.

B. References.

C. Submittals.

1. Submit detailed CAD-generated ductwork detail drawings at minimum ¼" scale, with details of the following:

a. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
b. Duct layout indicating pressure classification and sizes on plans.
c. Seam and joint construction.
d. Penetrations through fire-rated and other partitions.

e. Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.

NOTE: No installation of ductwork shall be allowed until detailed shop drawings have been reviewed by the Engineer. Any ductwork that is installed prior to the Engineer's review of the shop drawings shall be subject to removal and replacement at the Contractor's expense.

D. Performance requirements.

1. No variation of duct configuration or sizes shall be permitted except by written permission.
2. Structural Performance: Duct hangers, supports, and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7. SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." Reference Structural Design Criteria on General Structural Note Sheet in Structural Drawings for seismic hazard level classification.

a. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
b. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
c. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

E. Project record documents.

1. Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.
2. Provide copy of owner approval/acceptance of ductwork cleaning.
3. Provide copy of completed duct leakage test reports.

F. Qualifications.

1. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience.
2. Installer: Company specializing in performing the work of this section with minimum five years experience.

G. Regulatory requirements.

1. Construct all ductwork per codes listed in section 1.2.E

H. Environmental requirements.

1. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.

2. Maintain temperatures during and after installation of duct sealants.

2. PRODUCTS

2.1 METAL DUCTWORK

A. SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

1. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

    a. Reference SMACNA figure 2-9 and Drawings to construct gradual transitions where ductwork changes size or offsets.
    b. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.

2. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

    a. Transverse Duct Connection System

        1) Slide on flange system: Ductmate and Ductmate WDCI connection system complete with interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips. Gasket material shall be chemical resistant material in all fume exhaust ductwork.
        2) Formed on flange system: TDC, TDF or equivalent connection system or equivalent. Such flanges shall be constructed as SMACNA T-24 flange (Page 1-25 and 1-37 '85 SMACNA Duct Construction Manual, 1985 Edition).

3. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
4. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

a. Construct T's, and elbows in using radius of not less than 1-1/2 times width of duct on centerline. Where mitered rectangular elbows are used or indicated, provide turning vanes in accordance with Section 23 33 00.

5. Welded ductwork is to be weld with filler rod of the same material as the metal that is being welded. Coat welded joints with protective paint to prevent damage to galvanized surfaces.

B. SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

1. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

a. Round and oval duct shall be spiral lockseam duct with light reinforcing corrugations unless indicated otherwise.

2. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
3. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
b. Joints shall be minimum 2 inch insertion length for joint connections.
c. Transverse Duct Connection System

1) Slip type connector: Keating coupler.
2) Slide on flange system. Spiralmate and Ovalmate connection system complete with interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips. Gasket material shall be chemical resistant material in all fume exhaust ductwork.
3) Formed on flange system: Factory-applied Van Stone connection on one end of the duct with field-applied Van Stone connecter on the other end of the duct. Provide factory-applied Van Stone connections on each end of fittings.

4. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

5. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

a. Construct T's, bends, and elbows with minimum bend radius elbows shall be 1.5 times the duct diameter (major or minor axis on oval ductwork depending on direction of bend). Where not possible and where mitered elbows are used or indicated, provide turning vanes in accordance with Section 23 33 00.

6. Welded ductwork is to be weld with filler rod of the same material as the metal that is being welded. Coat welded joints with protective paint to prevent damage to galvanized surfaces.
7. On round and oval ducts, provide 45 deg wye tee take-offs or 90 deg conical tee take-offs or 45 degree low loss entry tee take-offs or other fitting as indicated on plans. Straight taps are not acceptable.

C. SHEET METAL MATERIALS

1. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
2. Galvanized Steel Ducts: ASTM A653 galvanized steel sheet, lock-forming quality, having G90 zinc coating of in conformance with ASTM A90. Provide mill-phosphatized finish for surfaces of ducts exposed to view.
3. Stainless Steel Ducts: ASTM A 480/A 480M, Type 316 sheet form with No. 4 finish for surfaces of ducts exposed to view, and Type 304 sheet form with No. 1 finish for
4. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
5. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

D. SEALANT AND GASKETS

1. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
2. Two-Part Tape Sealing System:

a. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
b. Tape Width: Min. 3 inches.
c. Sealant: Modified styrene acrylic.
d. Water resistant.
e. Mold and mildew resistant.
f. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
g. Service: Indoor and outdoor.
h. Service Temperature: Minus 40 to plus 200 deg F.
i. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
j. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Water-Based Joint and Seam Sealant:

a. Application Method: Brush on.
b. Solids Content: Minimum 65 percent.
c. Shore A Hardness: Minimum 20.
d. Water resistant.
e. Mold and mildew resistant.
f. VOC: Maximum 75 g/L (less water).
g. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
h. Service: Indoor or outdoor.
i. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

4. Flanged Joint Sealant: Comply with ASTM C 920.

a. General: Single-component, acid-curing, silicone, elastomeric.
b. Type: S.
c. Grade: NS.
d. Class: 25.
e. Use: O.
f. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

5. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
6. Round Duct Joint O-Ring Seals:

a. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
b. EPDM O-ring to seal in concave bead in coupling or fitting spigot.

c. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

E. FASTENERS

1. Rivets, bolts, or sheet metal screws.

2.2 INSULATED FLEXIBLE DUCTS

A. UL 181, Class 1, mechanically-locked spun nylon fabric supported by helically wound spring steel wire; fiberglass insulation; fire retardant polyethylene vapor barrier film.

B. Pressure Rating: 6 inches WG positive, 5.0 inches WG negative (through 16" diameter), 1.0' WG negative (18" to 20").

C. Maximum Velocity: 5500 fpm.

D. Temperature Range: -20 degrees F to 250 degrees F.

E. Minimum Sound Attenuation Performance (Insertion Loss in dB of 12' Length of 12" Round Duct):

1. 63 Hz Octave Band: 13
2. 125 Hz Octave Band: 37
3. 250 Hz Octave Band: 31
4. 500 Hz Octave Band: 34
5. 1 kHz Octave Band: 37
6. 2 kHz Octave Band: 47
7. 4 kHz Octave Band: 34

F. Manufacturer: Flexmaster Type 6B or equivalent.

3. EXECUTION

3.1 GENERAL

A. Install in accordance with manufacturer's instructions; SMACNA HVAC Duct Construction Standards - Metal and Flexible, current edition and International Mechanical Code requirements.

B. Seal ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, current edition.

C. Duct sizes are inside clear dimensions. For lined ducts, maintain sizes inside lining.

D. Duct transition from round to rectangular and vise versa shall be made with rectangular to round duct transition fitting.

E. Provide flange-type joint at transverse joints or seal as specified. All transverse joints shall be inspected by the Owner prior to insulating ductwork.

3.2 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install round and flat-oval ducts in maximum practical lengths.

a. Install round in lengths not less than 12 feet, unless interrupted by fittings.

C. Install ducts with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

H. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

I. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

1. During construction, provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system. Keep openings covered until ready for continuing duct run or final connections.

J. Construct and install each duct system for the specific duct pressure classification indicated.

K. Install only low loss high efficiency fittings at takeoffs. Extractors not allowed.

1. Air terminal take-offs from rectangular main ducts shall be lo-loss 45°F take-offs.
2. Diffusers and register take-offs from rectangular duct mains shall be lo-loss 45° fittings, with integral balancing damper that is provided with stand-off bracket and quadrant lock.
3. Exhaust grille/register branch duct connections to rectangular mains shall be lo-loss 45° entry fittings with integral balancing damper.

L. Install couplings tight to duct wall surface with a minimum of projections into duct.

M. Install ducts with a clearance of 2 inch, plus allowance for insulation thickness.

N. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

O. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire damper, sleeve, and firestopping sealant. Fire and smoke dampers are specified in Division 23 Section "Duct Accessories." Firestopping materials and installation methods are specified in Division 07 Section "Firestopping."

1. Refer to drawings for more information.

P. Verify location of air outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement. Refer to reflected ceiling plans, finish schedule, material finish specification, and shop drawings.

Q. Coordinate routing with all other trades to establish space requirements for each.

R. Contractor may vary route and shape of ductwork and make offsets during progress of work if required to meet structural or other interferences. Where such changes impair the system performance, the changes will be corrected at Contractor’s expense.

S. All ductwork shall be substantially and neatly supported on galvanized steel straps or angles riveted or bolted to duct flanges and properly anchored to the construction so that horizontal ducts are without sag or sway, vertical ducts are without buckle, and all ducts are free from the possibility of deformation, collapse or vibration. Support at each joint and at 4 feet on center maximum.

T. Openings required for ductwork through structural elements in new construction shall be coordinated with the General Contractor. Shop drawings locating such openings shall be prepared in ample time to meet the construction schedule.

U. Provide sleeves at all duct penetrations through walls, floors and roofs. Openings through sound-rated partitions shall have annular space stuffed with fiberglass insulation for full thickness of wall.

V. Provide 2-inch deep bitumastic coated drip pans on all non-ducted hoods, fans or penthouses used for relief or exhaust air service. Pans shall be 12 inches larger all around than roof opening with clear vertical openings between pan and structure as indicated. Insulate pan where indicated.

W. Where required on drawings, install automatic control dampers as recommended by the manufacturer.

X. Prevent passage of unfiltered air around filters with felt, rubber, neoprene gaskets, or other approved safing material.

Y. Provide openings in ductwork to accommodate thermometers and controllers. Provide pitot tube openings for testing of systems, complete with metal cap with spring device or screw to prevent air leakage.

Z. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

AA. Paint ductwork visible behind wall-mounted air outlets and inlets matte black.

1. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer.

BB. Change duct sizes gradually, not exceeding 30 degrees (15 degrees ideally) divergence and 45 degrees (30 degrees ideally) convergence.

CC. Use crimp joints with or without bead for joining round duct sizes 8 inches and smaller and install with crimp in direction of air flow.

DD. Provide return air grilles open to ceiling plenum with duct boot with minimum longitudinal dimension 2′ X 2′.

EE. Provide flexible connect between ductwork and all moving equipment.

1. Provide 1-inch slack for free movement.

FF. Join VAV boxes to medium pressure supply duct mains with minimum straight length of duct equal to 5 times box inlet diameter size. Duct to be rigid. Flexible ductwork is not allowed to join boxes to supply duct main.

GG. Threaded cap test holes shall be provided in all ductwork. Test holes shall be installed after the reheat coil in all VAV boxes. Provide extensions to allow for insulation thickness. Test holes shall be "Ventlok" or equal.

HH. Connect flexible ducts to metal ducts with stainless steel bands with worm gear tightener, nylon bands are unacceptable.

II. Unless otherwise noted, provide maximum of 6' of flexible duct upstream of each diffuser or grille. See details on Drawings.

JJ. Flexible ductwork shall not be used on ducted return or exhaust systems.

KK. Cover all exposed fiberglass insulation with duct tape.

3.3 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

F. Exposed ductwork serving ventilated workstations and corrosive storage cabinets:

1. Install the exposed stainless steel ductwork serving the ventilated workstations with the longitudinal weld facing the adjacent wall and away from public view. If possible, install one continuous exposed duct without transverse joints. Install escutcheon ring at ceiling penetration. Ring shall be same material and same finish as exposed duct. Note that exposed ductwork shall be provided with a No. 4 finish. Verify acceptable appearance of installed ductwork with Architect after installation.

G. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions, unless specifically indicated.

H. Provide closure flanges around exposed ductwork at wall and ceiling penetrations, 1-1/4 inches wide minimum.

3.4 INSTALLATION OF CLOTHES DRYER DUCTWORK

A. Installation. Clothes dryers shall be exhausted in accordance with the manufacturer's instructions. Dryer exhaust systems shall be independent of all other systems and shall convey the moisture and any products of combustion to the outside of the building.

B. Exhaust penetrations. Ducts that exhaust clothes dryers shall not penetrate or be located within any fireblocking, draftstopping or any wall, floor/ceiling or other assembly required by the International Building Code to be fire-resistance rated, unless such duct is constructed of galvanized steel or aluminum of the thickness specified in Section 603.3 and the fire-resistance rating is maintained in accordance with the International Building Code.

C. Cleanout. Each vertical riser shall be provided with a means for cleanout.

D. Exhaust installation. Dryer exhaust ducts for clothes dryers shall terminate on the outside of the building and shall be equipped with a backdraft damper. Screens shall not be installed at the duct termination. Ducts shall not be connected or installed with sheet metal screws or other fasteners that will be obstruct the exhaust flow. Clothes dryer exhaust ducts shall not be connected to a vent connector, vent or chimney. Clothes dryer exhaust ducts shall not extend into or through ducts or plenums.

E. Domestic clothes dryer ducts. Exhaust ducts for domestic clothes dryers shall be constructed of metal and shall have a smooth interior finish. The exhaust duct shall be a minimum nominal size of 4 inches (102mm) in diameter. The entire exhaust system shall be supported and secured in place. The male end of the duct at overlapped duct joints shall extend in the direction of airflow. Clothes dryer transition ducts used to connect the appliance to the exhaust duct system shall be limited to single lengths not to exceed 8 feet (2438 mm) and shall be listed and labeled for the application. Transition ducts shall not be concealed within construction.

F. Provide with chimney cap and backdraft damper.

3.5 INSTALLATION OF 2" AND GREATER PRESSURE CLASS DUCTWORK (POSITIVE OR NEGATIVE PRESSURE)

A. All round and oval duct elbows installed shall be die-formed, gored, pleated or mitered. All mitered elbows shall be equipped with turning vanes.

B. On round and oval ducts, provide 45 deg wye or 90 deg conical tee take-offs as indicated on plans. Straight taps are not acceptable.

C. All diverging flow fittings shall be constructed such that no excess material projects from the body into the branch tap entrance.

D. Transverse joints of all rectangular ducts greater than 24" wide or deep shall be fabricated with flanging system as called out previously (Ductmate or equivalent).

3.6 CLEANING

A. **The air handling units, energy recovery wheel, exhaust fans, and other HVAC airside equipment shall not be used for temporary building conditioning without the written permission from the Owner and Architect/Engineer.** Open ductwork that has been installed shall be protected during the duration of the project with polyethylene plastic and duct tape over the open ends. Uninstalled ductwork shall be protected from construction dust by covering the uninstalled ductwork with polyethylene plastic. Prior to installing ductwork, the inside of the ductwork shall be wiped down or vacuumed.

B. Clean inside all air handling units, energy recovery units, and outside air duct systems before the fans are turned on. Call for inspection by the owner's representative to verify that all ducts are cleaned. If the ductwork is unacceptable, the contractor shall provide vacuuming of these duct systems by forcing air at high velocity through duct where manual cleaning in not possible due to duct lengths or size. Call for re-inspection by Owner's representative.

C. Protect equipment which may be harmed by excessive dirt with temporary filters, or bypass during cleaning.

D. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.

E. Use service openings, as required, for physical and mechanical entry and for inspection.

F. Call for inspection by Owner's representative and provide documentation of owner approval to engineer and include copy in maintenance manuals.

G. Install a fresh set of filters in all equipment immediately prior to project turnover.

3.7 DUCTWORK SCHEDULE

Supply Air

Duct System:	Material:	Longitudinal Joints:	Transverse Joints:	Pressure Class:	Sealant Class:	Leakage Class:	Additional Notes:

Duct System:	Material:	Longitudinal Joints:	Transverse Joints:	Pressure Class:	Sealant Class:	Leakage Class:	Additional Notes:
Rectangular SA system upstream of terminal units	Galv. Steel	3A, 3E	4A, 4C, 4D	+6”	A	6	8B
Round SA system upstream of terminal units	Galv. Steel	3C, 3E	4B, 4D	+6”	A	3	8B, 8C
Rectangular SA system downstream of terminal units	Galv. Steel	3A, 3B, 3E	4A, 4C, 4D	+2”	A	24	8B
Round SA system downstream of terminal units	Galv. Steel	3C, 3E	4B, 4D	+2”	A	12	8B, 8C

Exhaust Air

Duct System:	Material:	Longitudinal Joints:	Transverse Joints:	Pressure Class:	Sealant Class:	Leakage Class:	Additional Notes:
Rectangular EA system downstream of terminal unit	Galv. Steel	3A, 3E	4A, 4C, 4D	-6”	A	6	8B
Round EA system downstream of terminal unit	Galv. Steel	3C, 3E	4B, 4D	-6”	A	3	8B, 8C
Rectangular EA system upstream of terminal unit	Galv. Steel	3E	4A	-2”	A	24	8B, 8C
Round EA system upstream of terminal unit	Galv. Steel	3C	4B	-2”	A	12	8B, 8C

Dedicated Biosafety Cabinet Exhaust Air Systems

Duct System:	Material:	Longitudinal Joints:	Transverse Joints:	Pressure Class:	Sealant Class:	Leakage Class:	Additional Notes:
Rectangular EA system between exhaust fan and BSC	Stainless Steel	3E	4D	-6”	A	6	8A, 8B
Round EA system between exhaust fan and BSC	Stainless Steel	3E	4D	-6”	A	3	8A, 8B, 8C

DUCTWORK SCHEDULE NOTES:

Longitudinal Joint Options:
3A: Pittsburgh lock. Refer to Figure 1-5, SMACNA.
3B: Button punch snap lock. Refer to Figure 1-5, SMACNA.
3C: Spiral lockseam.

3E: Welded.
3F: Double-wall, pre-manufactured sheet metal plenum.
3G: Butt-welded, fully-welded around entire perimeter of joint from outside in accordance with IMC.

Transverse Joint Options:
4A: Pre-manufactured flanged duct connection system specified under "Products" section of this specification.
4B 0-24" Major Axis Diameter: Interior slip coupling beaded at center, fastened to duct with sealing compound applied continuously around joint before assembling and after fastening.
26" Major Axis Diameter and Up: Pre-manufactured flanged duct connection system specified under "Products" section of this specification.
4C: Any standard transverse joint as shown in Figure 1-4 of SMACNA is acceptable.
4D: Welded
4E: Fully-welded at all joints from outside in accordance with IMC.

Sealant Class Options:
6: Seal class is defined by the following table (refer to Table 4-1, SMACNA HVAC Air Duct Leakage Test Manual):

Seal Class:	Sealing Required:
A	All transverse joints, longitudinal seams, and ductwork penetrations. Pressure sensitive tape shall not be used as a primary sealant on metal ducts.
B	All transverse and longitudinal seams. Pressure sensitive tape shall not be used as a primary sealant on metal ducts.
C	Transverse joints only.

Leakage:
7: Leakage Class is defined by Figure 4-1, SMACNA HVAC Air Duct Leakage Test Manual.

Additional Comments:
8A: See Drawings for further information regarding extent of stainless steel ductwork.
8B: Field welded ductwork is to be welded with filler rod of the same material as the metal that is being welded. Field coat welded joints with protective paint to prevent damage to galvanized surfaces.
8C: **Regardless if allowable by SMACNA, Snaplock longitudinal joints shall not be used for round ductwork.**

3.8 PRESSURE TESTING

A. Perform and complete the following field tests, inspections, and test reports according to SMACNA's "HVAC Air Duct Leakage Test Manual":

1. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
3. Maximum Allowable Leakage: Refer to paragraph 3.7.
4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.
5. Test no less than

    a. 100% of the ductwork

6. Submit completed test reports to engineer and include copy in maintenance manual.

END OF SECTION

SECTION 23 33 00
DUCTWORK ACCESSORIES

1. GENERAL

1.1 SECTION INCLUDES

A. Turning vanes.

B. Duct access doors.

C. Duct test holes.

D. Flexible duct connections.

E. Manual balancing dampers.

F. Gravity backdraft dampers.

G. Remote damper operators

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. References.

B. Submittals.

C. Project record documents.

1. Record actual locations of access doors, test holes etc.

D. Qualifications.

1. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience.

E. Regulatory requirements.

1. Products Requiring Electrical Connection: UL Listed and classified.

F. Delivery, storage, and handling.

G. Extra materials.

1. Provide two of each size and type of fusible link for fire and combination fire/smoke dampers.

2. PRODUCTS

2.1 TURNING VANES

A. General:

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
2. Note that air extractors or "scoops" shall not be used under any circumstances.

B. Manufactured and Fabricated Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
2. Single-Thickness Vane Construction: Vanes shall be single-thickness, quarter-circle shape with 2” radius, minimum 3.15” length, and spaced 1.5” on center.
3. Double-Thickness Vane Construction: Vanes shall be double-thickness, quarter-circle shape, with 4.5” radius and spaced 3.25” on center.

2.2 DUCT ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Double wall, rectangular door.
2. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
3. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.

a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches.
d. Access Doors Larger Than 24 by 48 Inches : Four hinges and two compression latches with outside and inside handles.
e. Fabricate doors airtight and suitable for duct pressure class.

4. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

2.3 DUCT TEST HOLES

A. Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

B. Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

2.4 FLEXIBLE DUCT CONNECTIONS

A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches to 5-3/4 inches wide attached to two strips of 2-3/4-inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch thick aluminum sheets. Provide metal compatible with connected ducts.

1. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

   a. Minimum Weight: 26 oz./sq. yd.
   b. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
   c. Service Temperature: Minus 40 to plus 200 deg F.

2. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

   a. Minimum Weight: 24 oz./sq. yd.
   b. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
   c. Service Temperature: Minus 50 to plus 250 deg F.

3. Fume Exhaust System, Flexible Connectors: Glass fabric with chemical-resistant coating.

   a. Minimum Weight: 14 oz./sq. yd.
   b. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
   c. Service Temperature: Minus 67 to plus 500 deg F.

4. Fan Discharge Flexible Connectors: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

    a. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
    b. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
    c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
    d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
    e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
    f. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
    g. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.5 MANUAL BALANCING DAMPERS

A. General:

1. Suitable for horizontal or vertical applications.
2. Fabricated in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.
3. Dampers shall have axles full length of damper blades and bearings at both ends of operating shaft.
4. **Provide 304 stainless steel construction when installed in stainless steel duct systems.**

B. Single Blade Dampers:

1. Ruskin models MD25 (rectangular), MDRS25 (round) or equivalent.
2. Fabricate for duct sizes up to 6 x 30 inch.
3. Frame: 20 gauge galvanized steel, 6” wide.
4. Blade: 20 gauge galvanized steel.
5. Control shaft / hand quadrant: 3/8” square axle shaft extending beyond frame through factory mounted, locking hand quandrant.

    a. Provide locking, indicating quadrant regulators on single and multi-blade dampers. Regulator shall be equivalent to Sheet Metal Connectors Model RP-3, with heavy-gauge steel regulator, wing nut locking assembly, and stamped dial indicating damper position.
    b. On externally insulated ducts, mount quadrant regulators on stand-off mounting brackets, bases, or adapters to avoid damaging or compression of insulation.

6. Bearings: Molded synthetic.
7. Finish: Mill galvanized.
8. Maximum velocity: 1500 fpm.
9. Maximum temperature: 250 deg F.

C. Multi-Blade Damper:

1. Ruskin model MD35 or equivalent.
2. Frame: 5" x 1" x 16 gauge galvanized steel channel with corner braces. Low profile top and bottom 3-1/2" x 3/8" x 16 gauge galvanized steel channel 13" high and under, actual.
3. Blade: 8" maximum width 16 gauge galvanized steel, opposed blade.
4. Blade stop: 20 gauge galvanized steel.
5. Finish: Mill galvanized.
6. Linkage: Exposed or concealed as recommended by manufacturer.
7. Axles: ½" hex.
8. Bearings: Molded synthetic.
9. Control shaft: 3" x 3/8" square plated steel, ½" dia. Jackshaft for multisection dampers.

    a. Jackshaft to operate multi-section damper from one side.

10. Temperature limits: -40 deg F min. to 240 deg F max.
11. Quadrants:

    a. Provide locking, indicating quadrant regulators on single and multi-blade dampers. Regulator shall be equivalent to Sheet Metal Connectors Model RP-3, with heavy-gauge steel regulator, wing nut locking assembly, and stamped dial indicating damper position.
    b. On externally insulated ducts, mount quadrant regulators on stand-off mounting brackets, bases, or adapters to avoid damaging or compression of insulation.
    c. Where rod lengths exceed 30 inches, provide regulator at both ends.

2.6 TAKEOFFS

A. Manufactured high-efficiency takeoff with 45-degree slope on the body, with gauge thickness equal to adjacent ductwork.

1. Damper may be provided with high-efficiency takeoff pending conformance with product requirements for manual balancing dampers.

2.7 GRAVITY BACKDRAFT DAMPERS

A. Multi-Blade, Parallel Action Gravity Balanced Backdraft Dampers: 16 gage thick extruded aluminum, with blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

B. Accessories

1. Flange Frame: 1-1/2 inches (38 mm), roll formed as part of frame.
2. Factory Sleeve: Aluminum. Minimum 0.080 inch (2.032 mm) thickness, minimum 8 inches (203 mm) length.
3. Bird or Insect Screen: Front or rear mounted to damper with mounting sleeve.

    a. Bird Screen: ½" x ½" x 0.063" woven aluminum intercrimped mesh.

4. Duct Transition Connection: Rectangular.

2.8 CABLE REMOTE DAMPER OPERATORS

A. Manufacturer: Metropolitan Air Technology or approved equivalent, model RT-250 (Round) and RT-200 (Rectangular).

B. RT-250:

1. Furnish cable operated remote controlled volume dampers in ducts located in inaccessible ceilings and where otherwise indicated. Reference architectural drawings for locations of gypsum board, spline etc. ceilings and other inaccessible damper locations. Damper frame (sleeve) construction shall be 20 gage (.91mm) roll formed, galvanized steel with beads at each end. Blades shall be 20 gage (.91mm) round single piece design, mechanically attached to the axle with support brackets. Axles shall be 3/8" (9.52mm) square plated steel with molded synthetic bearings housed in the damper frame. Damper control shaft shall be 3/8" (9.52mm) square shaft, minimum of 3" (75mm) long. Dampers shall be adjusted via a universal worm gear drive that is actuated by an unsheathed rotary cable which is captured at the damper end by a shaft coupling integral to the worm gear assembly. The rotary cable shall be terminated at the ceiling line or in a wall opening and concealed inside a ceiling/wall cup (RT-CCS, or RT-CCM) that is secured to the ceiling (or wall) framing. The cups shall provide a secure, unobtrusive appearance flush with the finished wall or ceiling. The universal damper drive shall be furnished as a complete assembly with universal mounting capabilities to accommodate damper shaft sizes from ¼"-3/8" square (6m – 9.5mm), or ¼"-1/2" (6mm- 12.7mm) round. The drive unit construction shall consist of a 14 gage galvanized mounting bracket, an aluminum worm and gear, and a black oxide coated steel drive shaft/cable coupling. Cable support clamps shall be factory furnished as required by the cable length. Ceiling Cup, rotary cable, and worm gear (damper drive system) shall be furnished as one piece for installation in the field with no linkage adjustment required or miscellaneous small parts. Direct, two-way damper control shall be provided without sleeves, springs, or screw adjustments (that may loosen after ceiling closure). Cable operated dampers shall be furnished with RT-WGA worm gear assembly and RT-CCM, or RT-CCS Ceiling Cups.BO-100 Construction:

C. RT-200:

1. Furnish cable operated remote controlled volume dampers in ducts located in inaccessible ceilings and where otherwise indicated. Reference architectural drawings for locations of gypsum board, spline etc. ceilings and other inaccessible damper locations. Damper frame (sleeve) construction shall be 16 gage (1.6 mm) galvanized steel channel frame. Blades shall be 16 gage (1.6 mm) galvanized steel V formed construction, mechanically attached to the axle with support brackets. Axles shall be 3/8" (9.52mm) square plated steel with molded synthetic bearings housed in the damper frame. Damper control shaft shall be 3/8" (9.52mm) square shaft, minimum of 3" (75mm) long. Dampers shall be adjusted via a universal worm gear drive that is actuated by an unsheathed rotary cable which is captured at the damper end by a shaft coupling integral to the worm gear assembly. The rotary cable shall be terminated at the ceiling line or in a wall opening and concealed inside a ceiling/wall cup (RT-CCS or RT-CCM) that is secured to the ceiling (or wall) framing. The cups shall provide a secure, unobtrusive appearance flush with the finished wall or ceiling. The universal damper drive shall be furnished as a complete assembly with universal mounting capabilities to accommodate damper shaft sizes from ¼"-3/8" square (6m – 9.5mm), or ¼"-1/2" (6mm- 12.7mm) round. The drive unit construction shall consist of a 14 gage galvanized mounting bracket, an aluminum worm and gear, and a black oxide coated steel drive shaft/ cable coupling. Cable support clamps shall be factory furnished as required by the cable length. Ceiling Cup, rotary cable, and worm gear (damper drive system) shall be furnished as one piece for installation in the field with no linkage adjustment required or miscellaneous small parts. Direct, two-way damper control shall be provided without sleeves, springs, or screw adjustments (that may loosen after ceiling closure). Cable operated dampers shall be furnished with RT-WGA worm gear assembly and RT-CCM or RT-CCS Ceiling Cups.

3. EXECUTION

3.1 PREPARATION

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

3.2 INSTALLATION

A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA HVAC Duct Construction Standards - Metal and Flexible. Refer to Section 23 31 13 for duct construction and pressure class.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts and stainless-steel accessories in stainless-steel ducts.

C. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. Upstream or downstream from duct silencers.
8. Control devices requiring inspection.
9. Elsewhere as indicated.

D. Unless duct access door size is explicitly indicated, provide minimum 24 x 18 inch size duct access doors wherever possible. Provide 18 x 18, 12 x 12 inch or 8 x 8 inch size elsewhere, using the largest size possible.

E. Install access doors with swing against duct static pressure.

F. Provide duct test holes where indicated and required for testing and balancing purposes. Install with minimum 24” clear dimension from any side wall or other obstruction.

G. Provide fire dampers, combination fire and smoke dampers and smoke dampers at locations indicated and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.

H. Coordinate installation of all fire dampers, combination fire and smoke dampers, and smoke dampers with all other disciplines to ensure a minimum of 24 x 24 inch clear horizontal access area from the ceiling vertically to the damper. The clear access area will be used for the inspection of damper fusible links and damper operators, as well as for the resetting of damper. Clear access areas and appropriate wall/ceiling access panels, if required, shall be clearly shown on the coordination drawings.

I. Install smoke dampers and combination smoke and fire dampers in accordance with NFPA 92A.

J. All fire and combination fire/smoke dampers shall be commissioned (tested) in the presence of Owner representative following installation and before the corresponding fan systems are turned on. Contractor shall open all access doors for the inspection and close all doors in the presence of the inspector.

K. Demonstrate re-setting of fire dampers to Owner's representative.

L. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment, and supported by vibration isolators. Install flexible connectors with adequate flexibility to allow for all thermal, axial, transverse and torsional movement. Provide airtight seal.

M. Provide balancing dampers at points on supply, return, and exhaust systems where indicated on plans.

N. Set dampers to fully open position before testing, adjusting, and balancing.

O. Provide a high-efficiency takeoff with 45-degree entry for each branch connection.

P. Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.

Q. The use of splitter dampers is not acceptable.

R. Install remote damper actuators where the balance damper is not accessible. Field paint the remote actuator cap to match the adjacent ceiling finish.

1. In these areas, the contractor shall provide and install damper in ductwork and shall connect damper to terminal point in ceiling with Bowden control wire.
2. Install per manufacturer instructions.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION

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SECTION 23 34 23
HVAC POWER VENTILATORS

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Utility set fans.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on 760 FT.

1.4 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

1. Performance ratings: Conform to ANSI/AMCA Standards 210 and 300. Fans must be tested in accordance with AMCA Publications 211 and 311 in an AMCA accredited laboratory and certified for air and sound performance. Fans shall be licensed to bear the AMCA ratings seal for air performance (AMCA 210).
2. Fans shall have a Fan Energy Index (FEI) rating that meets or exceeds requirements of the latest edition of ASHRAE 90.1.
3. Fans shall be licensed to bear the Air Movement and Control Association (AMCA) Certified Ratings Program (CRP) seal for FEI.
4. The Fan FEI rating shall be indicated on the design documents and manufacturer product submittals to allow for compliance verification by the building official.
5. Classification for Spark Resistant Construction shall conform to ANSI/AMCA Standard 99.
6. Each fan shall be given a balancing analysis which is applied to wheels at the outside radius. The maximum allowable static and dynamic imbalance is 0.05 ounces (Balance grade of G6.3)
7. Comply with the National Electrical Manufacturers Association (NEMA) standards for motor and electrical accessories.
8. Each fan shall undergo a factory run test where fan RPM and amp draw are recorded. This information is available to the customer free of charge upon request.

B. References.

1. ANSI/AMCA Standard 99-10, “Standards Handbook”
2. ANSI/AMCA Standard 204-05, “Balance Quality and Vibration Levels for Fans”
3. ANSI/AMCA Standard 210-07, “Laboratory Methods of Testing Fans for Aerodynamic Performance Rating”
4. AMCA Publication 211-05, “Certified Ratings Program – Product Rating Manual for Fan Air Performance”
5. ANSI/AMCA Standard 300-08, “Reverberant Room Method for Sound Testing of Fans”
6. AMCA Publication 311-05, “Certified Ratings Program – Product Rating Manual for Fan Sound Performance”
7. AMBA - Method of Evaluating Load Ratings of Bearings ANSI-11 (r1999).
8. AMCA Standard 500-D-12, “Laboratory Methods of Testing Dampers for Rating”
9. OSHA guideline 1910.212 – General requirements for Machine Guarding. (www.osha.gov)
10. OSHA guideline 1910.219 – General requirements for guarding safe use of mechanical power transmission apparatus. (www.osha.gov)
11. OSHA guideline 1926.300 – General requirements for safe operation and maintenance of hand and power tools. (www.osha.gov)
12. UL/cUL 705, Power Ventilators

C. Submittals.

1. Provide dimensional drawings and product data on each centrifugal fan.
2. Provide fan curves for each fan at the specified operation point, with the flow, static pressure and horsepower clearly plotted.
3. Provide outlet velocity of centrifugal fans and fan’s inlet and outlet sound power readings for the eight octave bands.
4. Strictly adhere to QUALITY ASSURANCE requirements as stated in section 1.4 of this specification.
5. Provide manufacturer’s certification that exhaust fan is licensed to bear the Air Movement and Control Association (AMCA) Certified Rating Seal for air performance and sound performance where applicable.
6. Provide manufacturer’s Installation, Operation and Maintenance manual (IOM), including instructions on safety information, receiving, handling, and storage, installation, electrical wiring diagrams, operation, maintenance, troubleshooting guide, and warranty.

D. Operation and maintenance manuals.

E. Project record documents.

F. Delivery, storage, and handling.

1. Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer, material, products included, and location of installation.
2. Store materials in a dry area indoor, protected from damage, and in accordance with manufacturer's instructions. For long term storage, follow manufacturer's Installation, Operation and Maintenance manual.
3. Handle and lift fans in accordance with the manufacturer's instructions. Protect materials and finishes during handling and installation to prevent damage. Follow all safety warnings posted by the manufacturer.

G. Warranty.

1. Submit, for Owner's acceptance, manufacturer's standard warranty document executed by authorized company official. Manufacturer's warranty is in addition to, and not a limitation of, other rights Owner may have under Contract Documents.

   a. The warranty of this equipment is to be free from defects in material and workmanship for a period of one year from the purchase date. Any units or parts which prove defective during the warranty period will be replaced at the manufacturers' option when returned to the manufacturer, transportation prepaid.
   b. Motor Warranty is warranted by the motor manufacturer for a period of one year. Should motors furnished prove defective during this period, they should be returned to the nearest authorized motor service station.

2. PRODUCTS

2.1 UTILITY SET FANS

A. Acceptable manufacturers:

1. Greenheck
2. Or approved equivalent.

B. General:

1. Base fan performance at standard conditions (density 0.075 Lb/ft^3).
2. Fans selected shall be capable of accommodating static pressure and flow variations of +/-15% of scheduled values.
3. Each fan shall be direct drive in AMCA arrangement 4 according to drawings.
4. Normal operating temperature up to 104 Degrees Fahrenheit (40 Deg. Celsius).
5. Each fan shall bear a permanently affixed manufacture's engraved metal nameplate containing the model and individual serial number.
6. Fans are to be equipped with lifting lugs.
7. Constructed of heavy gauge steel

8. After fabrication, untreated steel components go through a multi-stage cleaning and pre-treatment process before being finished with a high-performance powder coating having a minimum thickness of 2-4 mils, electrostatically applied and baked. Finish color shall be RAL-7023, concrete grey. Coating must exceed 1,000-hour salt spray under ASTM B117 test method. No uncoated metal fan parts will be allowed.

C. Fan Housing and Outlets

1. Fan housing is to be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.
2. Fan shall be of airtight PermaLock™ construction with the scroll panel material formed and embedded into the side panels. All interior and exterior surface untreated steel shall be coated with a high-performance powder coating.
3. Arrangement 4 has fan wheel directly coupled to the motor shaft.
4. Housing and bearing support shall be constructed of bolted framework.
5. An OSHA compliant shaft guard shall be included to completely cover the shaft for arrangement 8 only.

D. Fan Wheel

1. The fan wheel shall be of the single width backward inclined centrifugal type.
2. Fan Wheel shall be statically and dynamically balanced to balance grade G6.3 per ANSI S2.19.
3. The wheel and fan inlet shall be carefully matched and shall have precise running tolerances for maximum performance and operating efficiency.

E. Fan Motors and Drive

1. AC induction motor type

   a. Motors shall meet or exceed EISA (Energy Independence and Security Act) efficiencies. Motors to be NEMA T-frame, 690, 870, 1170, 1770 or 3500 RPM in 60 Hz, (720, 950, 1425 or 2900 in 50 Hz) Open Drip Proof (ODP) or Totally Enclosed Fan Cooled (TEFC).

2. EC Motor type

   a. Motors shall be open type enclosure and electronic commutation type motor (ECM) specifically designed for fan applications. Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase. Internal motor circuitry to convert AC power supplied to the fan to DC power to operate the motor. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted at the motor or by a 0-10 VDC signal. Motor shall be a minimum of 85% efficient at all speeds.

F. Fans shall be licensed to bear the AMCA ratings seal for air performance (AMCA 210) and sound performance (AMCA 300).

3. EXECUTION

3.1 EXAMINATION

A. Examine areas to receive fans. Notify the Engineer of conditions that would adversely affect installation or subsequent utilization and maintenance of fans. Do not proceed with installation until unsatisfactory conditions are corrected.

3.2 INSTALLATION

A. Install fans systems as indicated on the contract drawings.

B. Install fans in accordance with manufacturer's Installation, Operation and Maintenance manual.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION

SECTION 23 36 00
AIR TERMINAL UNITS

1. GENERAL

1.1 SECTION INCLUDES

A. Variable volume terminal units.

B. Integral wiring and controls.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. References.

B. Submittals.

1. Include schedules listing discharge and radiated sound power level for each of second through sixth octave bands at inlet static pressures of 1 to 4 inch wg.

C. Project record documents.

D. Operation and maintenance data.

1. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant volume regulators.

E. Qualifications.

1. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five (5) years documented experience.

F. Regulatory requirements.

1. Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories Inc., as suitable for the purpose specified and indicated.

G. Warranty.

1. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant volume regulators.

2. PRODUCTS

2.1 SINGLE DUCT VARIABLE VOLUME UNITS

A. See Drawings for further information.

B. Basic Assembly:

1. Casings: Minimum 22 galvanized steel.
2. Liner: Fiber-free internal liner.
3. Air Outlets: S slip and drive connections.
4. ARI Certified

C. Basic Unit:

1. Configuration: Air volume damper assembly inside unit casing. Locate control components inside protective metal shroud.
2. Volume Damper: Construct of steel with peripheral gasket and self lubricating bearings; maximum damper leakage: 4 percent of design air flow at three (3) inches inlet static pressure.
3. Mount damper operator to position damper normally open or normally closed as required by the operation sequence.
4. On units with heating coils, provide minimum 9”x6” hinged and gasketed access door on bottom of unit to facilitate coil inspection.

D. Velocity Sensors: Removable multipoint array at air inlet.

E. Hot Water Heating Coil:

1. Construction: 1/2 inch copper tube mechanically expanded into aluminum plate fins, leak tested under water to 200 psig pressure, factory installed.
2. Provide factory-insulated coil bends.
3. Capacity: As scheduled.

2.2 WIRING

1. Factory-mount and wire controls. Mount electrical components in control box with removable cover. Incorporate single point electrical connection to power source.
2. Factory mount transformer. Provide terminal strip in control box for field wiring of thermostat and power source.

3. Wiring Terminations: Wire fan and controls to terminal strip. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.
4. Disconnect Switch: As scheduled.

2.3 CONTROLS

1. Direct digital controls: Contain in NEMA-1 enclosure with access panel sealed from air flow and mounted on side of unit. Factory-mount controls.

3. EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide ceiling access doors or locate units above easily removable ceiling components. In no instance shall units be installed in inaccessible locations.

C. Support units individually from structure. Do not support from adjacent ductwork.

D. Connect to ductwork in accordance with Section 23 31 13.

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

F. Maintain a minimum of 18” clearance in front of VAV controller.

G. Provide 3 straight duct diameters upstream of VAV box inlet.

H. Flexible duct connections to VAV boxes are not permitted.

3.2 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 23 05 53 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.3 ADJUSTING

A. Reset volume with damper operator attached to assembly allowing flow range modulation as indicated on equipment schedule.

END OF SECTION

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SECTION 23 37 00
AIR OUTLETS AND INLETS

1. GENERAL

1.1 SECTION INCLUDES

A. Diffusers.

B. Registers/grilles.

1.2 REFERENCES

A. See Section 23 05 00.

1.3 SUBMITTALS

A. See Section 23 05 00.

1.4 PROJECT RECORD DOCUMENTS

A. See Section 23 05 00.

1.5 QUALITY ASSURANCE

A. Test and rate air outlet and inlet performance in accordance with ADC Equipment Test Code 1062 and ASHRAE 70.

B. Test and rate louver performance in accordance with AMCA 500. Submit AMCA certification with submittal.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five (5) years documented experience.

2. PRODUCTS

2.1 CEILING DIFFUSERS

A. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide ceiling air diffusers that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

C. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air diffuser.

D. Types: Provide ceiling diffusers of type, capacity, and with accessories and finishes as listed on diffuser schedule.

2.2 WALL REGISTERS AND GRILLES

A. General: Except as otherwise indicated, provide manufacturer's standard wall registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide wall registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device and listed in manufacturer's current data.

C. Wall Compatibility: Provide registers and grilles with border styles that are compatible with adjacent wall systems, and that are specifically manufactured to fit into wall construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of wall construction which will contain each type of wall register and grille.

D. Types: Provide wall registers and grilles of type, capacity, and with accessories and finishes as listed on register and grille schedule.

3. EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.

C. Install diffusers to ductwork with adjustable elbow. Install maximum length of 5' of flexible duct upstream of each diffuser and grille, unless otherwise noted. See details on Drawings. All connections shall be air tight.

D. In laboratories with ventilated workstations, position diffusers so that airflow is directed parallel to the front of the workstation, not perpendicular to it.

E. Where diffusers are located near fume hoods, canopy hoods, biological safety cabinets, or other devices which are sensitive to air turbulence, install diffuser to direct airflow parallel to the front face of the device (i.e. not directed at device).

F. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly. Where a balancing damper has been omitted from drawing, consult engineer.

G. Paint ductwork visible behind air outlets and inlets matte black.

H. Provide return air sound boot on grilles as shown on drawings.

I. Where slot diffusers or linear diffusers are located near perimeter windows, adjust at least one slot to direct air toward window.

END OF SECTION

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SECTION 23 52 00 – HEATING BOILERS

1. GENERAL

1.1 SECTION INCLUDES

A. This Section includes packaged, factory-fabricated and assembled, gas-fired, fire-tube condensing boilers, trim, and accessories for space heating hot water.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

A. Quality assurance.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.

D. "ASHRAE/IESNA 90.1 Compliance" Paragraph may be required to comply with Project requirements or authorities having jurisdiction. Also, LEED Prerequisite EA 2 requires compliance with ASHRAE/IESNA 90.1.

E. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

F. ANSI Compliance: Boilers shall be compliant with ANSI Z21.13 test standards for US and Canada.

G. CSA Compliant: Boilers shall be compliant with CSA certification.

H. References.

1. ASME Section IV
2. CAN-1.3.1-77, Industrial and Commercial Gas Fired Packaged Boilers
3. CSD-1, Controls and Safety Devices
4. XL GAPS
5. NEC, National Electric Code
6. UL-795 7th Edition
7. AHRI, BTS-2000
8. ASHRAE 90.1-2010

I. Submittals.

1. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: For boilers, boiler trim, and accessories.

    a. Include plans, elevations, sections, details, and attachments to other work.
    b. Wiring Diagrams: Power, signal, and control wiring.

3. Source quality-control test reports: Indicate and interpret test results for compliance with performance requirements before shipping.
4. Field quality-control test reports: Indicate and interpret test results for compliance with performance requirements.
5. Warranty: Standard warranty specified in this Section.

J. Operation and maintenance manuals.

K. Project record documents.

1. Complete parts list
2. Certified startup and combustion test record

L. Delivery, storage, and handling.

1. Handle boiler components and equipment carefully to prevent damage, breaking, and scoring. Do not install damaged components; replace with new.
2. Store boiler sections and equipment in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.
3. Comply with manufacturer's rigging and moving instructions for unloading boilers, and moving them to final location.

M. Regulatory requirements

N. Coordination:

1. Mechanical contractor shall coordinate the size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete reinforcement and formwork requirements are specified in Division 03.

O. Warranty:

1. Standard Warranty: Boilers shall include manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.

a. Warranty Period for Fire-Tube Condensing Boilers:

1) Heat Exchanger, Pressure Vessel and Condensation Collection Basin shall carry a 10 year limited warranty against defects in materials or workmanship and failure due to thermal shock.
2) All other components shall carry a one year warranty from date of boiler start up.

2. PRODUCTS

2.1 BOILERS

A. Manufacturers:

1. Lochinvar Knight FTXL Boiler as specified on Drawings or approved equivalent.

B. Construction:

1. Description: Boiler shall be natural gas fired, fully condensing, and fire tube design. The boiler shall be factory-fabricated, factory-assembled, and factory-tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls.
2. Heat Exchanger: The heater exchanger shall bear the ASME “H” stamp for 160 psi working pressure and shall be National Board listed. The heat exchanger shall be constructed of a fully welded stainless steel and of fire tube design. The heat exchanger shall be designed for a single-pass water flow to limit the water side pressure drop. Cast iron, aluminum, or condensing copper tube boilers will not be accepted.
3. Efficiency: Boilers shall have an AHRI certified minimum thermal efficiency of 97 percent.
4. Condensate Collection Basin: Fully welded stainless steel and shall include a stainless steel combustion analyzer test port.
5. Pressure Vessel: The pressure vessel shall be in accordance with ASME Section IV pressure vessel code. The pressure vessel shall be designed for a single-pass water flow to limit the water side pressure drop. The pressure vessel shall contain a volume of water no less than:

Model	Water Content
FTX400	13 gallons
FTX500	12 gallons
FTX600	12 gallons
FTX725	17 gallons
FTX850	16 gallons
FTX1000	19 gallons

6. Burner: Natural gas, forced draft single burner premix design. The burner shall be high temperature stainless steel with a woven Fecralloy outer covering to provide modulating firing rates. The burner shall be capable of the stated gas train turndown without loss of combustion efficiency.
7. Blower: Boiler shall be equipped with a pulse width modulating blower system to precisely control the fuel/air mixture to provide modulating boiler firing rates for maximum efficiency. The burner firing sequence of operation shall include pre-purge, firing, modulation, and post-purge operation.

    a. Motors: Comply with requirements specified in Division 23 Section "Electrical Requirements for Mechanical Equipment."

8. Gas Train: The boiler shall be supplied with a negative pressure regulation gas train and shall be capable of the following minimum turndowns:

Model	Turndown	Minimum Input	Maximum Input
FTX400	10:1	40,000	400,000
FTX500	10:1	50,000	500,000
FTX600	7:1	85,700	600,000
FTX725	7:1	103,500	725,000
FTX850	7:1	121,500	850,000
FTX1000	10:1	99,900	999,000

9. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
10. Casing:

    a. Jacket: Heavy gauge primed and painted steel jacket with snap-in closures.
    b. Control Compartment Enclosures: NEMA 250, Type 1A.
    c. If retaining second option in "Jacket" Subparagraph above, delete first subparagraph below.
    d. Insulation: Minimum ½ inch thick, mineral fiber insulation surrounding the heat exchanger.
    e. Combustion-Air Connections: Inlet and vent duct collars.

11. Characteristics and Capacities:

a. Heating Medium: Hot water.
b. Design Water Pressure Rating: 160 psi working pressure.
c. Safety Relief Valve Setting: 50 psig
d. Minimum Water Flow Rate:

Model	Minimum Flow
FTX400	10 gpm
FTX500	12 gpm
FTX600	15 gpm
FTX725	18 gpm
FTX850	21 gpm
FTX1000	30 gpm

C. Trim

1. Safety Relief Valve:

a. Size and Capacity: 50 lb.
b. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.

2. Pressure Gage: Minimum 3-1/2 inch diameter. Gage shall have normal operating pressure about 50 percent of full range.
3. Drain Valves: Minimum NPS 3/4 or nozzle size with hose-end connection.
4. Condensate Neutralization Kit: Factory supplied condensate trap with condensate trip sensor, high capacity condensate receiver prefilled with appropriate medium.

D. Controls

1. Refer to Division 23 Section "Instrumentation and Control for HVAC."
2. Boiler controls shall feature a standard, factory installed multi-color graphic LCD screen display with navigation dial and includes the following standard features:

a. Con-X-Us capable: Boiler shall have the ability to communicate remotely using the optional Con-X-Us software via a wireless or Ethernet connection.
b. Password Security: Boiler shall have a different password security code for the User and the Installer to access adjustable parameters.
c. Ramp delay: Boiler may be programmed to limit the firing rate based on six limits steps and six time intervals.
d. PC port connection: Boiler shall have a PC port allowing the connection of PC boiler software.
e. Maintenance reminder: Boiler shall have the ability to display a yellow colored, customizable maintenance notification screen. All notifications are adjustable by

the installer based upon months of installation, hours of operation, and number of boiler cycles.

f. English Error codes: Boiler shall have a user interface that displays a red error screen with fault codes that are displayed in English and include a date and time stamp for ease of servicing.

g. Anti-cycling control: Boiler shall have the ability to set a time delay after a heating demand is satisfied allowing the boiler to block a new call for heat. The boiler will display an anti-cycling blocking on the screen until the time has elapsed or the water temperature drops below the anti-cycling differential parameter. The anti-cycling control parameter is adjustable by the installer.

h. Isolation valve control: Boiler shall have the ability to control a 2-way motorized control valve. Boiler shall also be able to force a fixed number of valves to always be energized regardless of the number of boilers that are firing.

i. BMS integration with 0-10V DC input: The Control shall allow an option to Enable and control set point temperature or control firing rate by sending the boiler a 0-10V input signal.

j. Data logging: Boiler shall have non-volatile data logging memory including last 10 lockouts, space heat run hours, domestic hot water run hours and ignition attempts. All data should be visible on the boiler screen.

3. The boiler shall have a built in Cascade controller to sequence and rotate lead boiler to ensure equal runtime while maintaining modulation of up to 8 boilers of different btu inputs without utilization of an external controller. The factory installed, internal cascade controller shall include:

a. Lead lag: The Control module shall allow only one boiler to fire at the beginning of a call for heat. Once the lead boiler is in full fire and the control calculates that additional heat is required it will call on an additional boiler as needed.

b. Efficiency optimization: The Control module shall allow multiple boilers to simultaneously fire at minimum firing rate in lieu of Lead/Lag.

c. Front end loading: The Control module shall allow the cascading and functional control of several non condensing Lochinvar products alongside the Knight FTXL.

d. Rotation of lead boiler: The Control module shall change the lead boiler every hour for the first 24 hours after initializing the Cascade. Following that, the leader will be changed once every 24 hours.

4. Boiler operating controls shall include the following devices and features:

a. Set-Point Adjust: Set points shall be fully adjustable by the installer.

b. Sequence of Operation: Factory installed controller to modulate burner firing rate to maintain system water temperature in response to call for heat.

5. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation and include:

a. High Temperature Limit: Automatic and manual reset stops burner if operating conditions rise above maximum boiler design temperature. Limit switch to be manually reset on the control interface.
b. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manually reset on the control interface.
c. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
d. High and Low Gas Pressure Switches: Pressure switches shall prevent burner operation on low or high gas pressure. Pressure switches to be manually reset on the control interface.
e. Blocked Drain Switch: Blocked drain switch shall prevent burner operation when tripped. Switch to be manually reset on the control interface.
f. Low air pressure switch: Pressure switches shall prevent burner operation on low air pressure. Switch to be manually reset on the control interface.
g. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for any lockout conditions.

6. Building Automation System Interface:

a. Boiler shall have the ability to receive a 0-10V system from a building management system and control by the following:

1) 0-10V DC input to control Modulation or Setpoint
2) 0-10V DC input Enable/Disable signal

b. Factory installed Modbus gateway interface to enable building automation system to monitor, control, and display boiler status and alarms.

E. Electrical Power:

1. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.
2. Single-Point Field Power Connection: Factory-installed and factory-wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
3. Electrical Characteristics:

a. See Drawings
b. Voltage

1) 120V / 1PH

c. Frequency: 60 Hz

F. Venting:

1. Exhaust flue must be Category IV approved CPVC, PP or stainless steel sealed vent material from one of the approved manufacturers listed in the Installation and Operation manual. Boilers exhaust vent length must be able to extend to 100 equivalent feet.
2. Intake piping must be of approved material as listed in the Installation and Operations manual. Boilers intake pipe length must be able to extend to 100 equivalent feet.
3. Boiler venting and intake piping configuration shall be installed per one of the approved venting methods shown in the Installation and Operation manual.
4. Boilers using common venting must only include like models and the optional common vent damper. Contact the factory for common vent sizing.
5. Boiler shall come standard with a flue sensor to monitor and display flue gas temperature on factory provided LCD display.
6. Refer to manufacturer's Installation and Operations manual for detailed venting instructions and approved manufacturers.

G. Source quality control

1. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
2. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

3. EXECUTION

3.1 EXAMINATION

1. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.

    a. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

2. Examine mechanical spaces for suitable conditions where boilers will be installed.
3. Proceed with installation only after satisfactory conditions have been verified.

3.2 BOILER INSTALLATION

A. Install equipment on 4" concrete housekeeping pad.

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

A. Install boilers level on concrete bases. Concrete base is specified in Division 23 Section "Common Work Results for HVAC," and concrete materials and installation requirements are specified in Division 03.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of equipment connection. Provide a reducer if required.

E. Connect hot-water piping to supply and return boiler tappings with shutoff valve and union or flange at each connection.

F. Install piping from safety relief valves to nearest floor drain.

G. Boiler Venting:

1. Install flue venting kit and combustion-air intake.
2. Connect full size to boiler connections. Comply with requirements in Division 23 Section “Breechings, Chimneys, and Stacks.

H. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

I. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and inspections:

1. Perform installation and startup checks according to manufacturer's written instructions. Complete startup form included with Boiler and return to Manufacturer as described in the instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

    a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
    b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

5. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

3.5 DEMONSTRATION

A. Engage a factory representative or a factory-authorized service representative for boiler startup. Start-up sheet shall be completed and a copy shall be sent to the Engineer and the Manufacturer. A combustion analysis shall be completed and the gas valve adjusted per the Installation and Operations manual and note in start-up report.

B. Factory representative or a factory-authorized representative shall provide Owners training to instruct maintenance personnel to adjust, operate, and maintain boilers.

END OF SECTION

SECTION 23 74 13 – DEDICATED OUTDOOR AIR SYSTEM

1. GENERAL

1.1 RELATED DOCUMENTS

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

B. Specification section 23 05 00.

1.2 SUMMARY

A. This Section includes:

1. Energy recovery heating and cooling units.

B. Related Sections include the following:

1. Division 23 09 00 Section "Digital Control Equipment".

1.3 SUBMITTALS

A. Product Data: Include manufacturer's technical data for each model indicated, including rated capacities of selected model clearly indicated; dimensions; required clearances; shipping, installed, and operating weights; furnished specialties; accessories; and installation and startup instructions.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.

1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C. Commissioning Reports: Indicate results of startup and testing commissioning requirements. Submit copies of completed checklists.

D. Maintenance Data: Maintenance manuals specified in 23 05 00.

E. Warranties: Special warranties specified in this Section.

1.4 QUALITY ASSURANCE

A. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."

B. Energy Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

C. Listing and Labeling: Provide electrically operated components specified in this Section that are listed and labeled.

1. The rooftop unit(s) shall be certified in accordance with UL Standard 1995 and ANSI Standard Z21.47.
2. The rooftop unit(s) shall be safety certified by an accredited testing laboratory and the nameplate shall carry the label of the certification agency.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver rooftop units as factory-assembled units with protective crating and covering as recommended by the manufacturer.

B. Coordinate delivery of units in sufficient time to allow movement into building.

C. Handle rooftop units to comply with manufacturer's written rigging and installation instructions for unloading and moving to final location.

1.6 COORDINATION

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations with roof construction.

1.7 WARRANTY

A. General Warranty

B. Special Warranty: A written warranty, executed by the manufacturer and signed by the Contractor, agreeing to replace components that fail in materials or workmanship, within the specified warranty period, provided manufacturer's written instructions for installation, operation, and maintenance have been followed. (See section 3.5 A)

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

1. Filters: One set of filters for each unit.

2. PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to strict compliance with the requirements of this specification, provide products by one of the following:

1. Rooftop Units:

a. Daikin
b. Trane
c. Aaon, Inc.
d. LG Air Conditioning Technologies
e. Or Approved Equivalent

B. GENERAL DESCRIPTION

1. Configuration: Fabricate as detailed on prints and drawings:

a. Return plenum / economizer section
b. Filter section
c. Cooling coil section
d. Supply fan section
e. Gas heating section.
f. Condensing unit section

2. The complete unit shall be cETLus listed.
3. The unit shall be ASHRAE 90.1-2016 compliant and labeled.
4. Each unit shall be specifically designed for outdoor rooftop application and include a weatherproof cabinet. Each unit shall be completely factory assembled and shipped in one piece. Packaged units shall be shipped fully charged with R-410 Refrigerant and oil.
5. The unit shall undergo a complete factory run test prior to shipment. The factory test shall include a refrigeration circuit run test, a unit control system operations checkout, a unit refrigerant leak test and a final unit inspection.
6. All units shall have decals and tags to indicate caution areas and aid unit service. Unit nameplates shall be fixed to the main control panel door. Electrical wiring diagrams shall be attached to the control panels. Installation, operating and maintenance bulletins and start-up forms shall be supplied with each unit.

7. Performance: All scheduled EER, IEER, capacities and face areas are minimum accepted values. All scheduled amps, kW, and HP are maximum accepted values that allow scheduled capacity to be met.
8. Warranty: The manufacturer shall provide 12-month parts only warranty. Defective parts shall be repaired or replaced during the warranty period at no charge. The warranty period shall commence at startup or six months after shipment, whichever occurs first.

C. CABINET, CASING, AND FRAME

1. Panel construction shall be double-wall construction for all panels. All floor panels shall have a solid galvanized steel inner liner on the air stream side of the unit to protect insulation during service and maintenance. Insulation shall be a minimum of 1" thick with an R-value of 7.0, and shall be 2 part injected foam. Panel design shall include no exposed insulation edges. Unit cabinet shall be designed to operate at total static pressures up to 5.0 inches w.g.
2. Exterior surfaces shall be constructed of painted galvanized steel, for aesthetics and long-term durability. Paint finish will include a base primer with a high-quality polyester resin topcoat. Finished, unabraded panel surfaces shall be exposed to an ASTM B117 salt spray environment and exhibit no visible red rust at a minimum of 3,000 hours exposure. Finished, abraded surfaces shall be tested per ASTM D1654, having a mean scribe creepage not exceeding 1/16” at 1,000 hours minimum exposure to an ASTM B117 salt spray environment. Measurements of results shall be quantified using ASTM D1654 in conjunction with ASTM D610 and ASTM D714 to evaluate blister and rust ratings.
3. Service doors shall be provided on the fan section, filter section, control panel section, and heating vestibule in order to provide user access to unit components. All service access doors shall be mounted on multiple, stainless steel hinges and shall be secured by a latch system. Removable service panels secured by multiple mechanical fasteners are not acceptable.
4. The unit base shall overhang the roof curb for positive water runoff and shall seat on the roof curb gasket to provide a positive, weathertight seal. Lifting brackets shall be provided on the unit base to accept cable or chain hooks for rigging the equipment.

D. OUTDOOR/RETURN AIR SECTION

1. Unit shall be provided with a 100% outdoor air hood. The 100% outdoor air hood shall allow outdoor air to enter from the back of the unit, at the draw-through filter section. The outdoor air hood shall be factory installed and constructed from galvanized steel finished with the same durable paint finish as the main unit. The hood shall include a bird screen to prevent infiltration of foreign materials and a rain lip to drain water away from the entering air stream.
2. Low leak dampers shall be provided. Damper blades shall be fully gasketed and side sealed and arranged vertically in the hood. Damper leakage shall be less than 1.5 CFM/Sq. Ft. of damper area at 1.0 inch static pressure differential. Leakage rate to be tested in accordance with AMCA Standard 500. Damper blades shall be operated from

multiple sets of linkages mounted on the leaving face of the dampers. Control of the dampers shall be from a factory installed actuator.

3. Control of the outdoor dampers shall be by a factory installed actuator. Damper actuator shall be of the modulating type. Damper to open when supply fan starts, and close when supply fan stops.

E. ENERGY RECOVERY

1. The fixed plate energy recovery core is equipped with a bypass damper on the outside air path. If the RTU has an economizer internal to it then the bypass damper will open when the unit enters the economizer operating state and close when the unit leaves the economizer operating state.
2. When the outside air is below 32F (adjustable) the bypass damper will open for 5 minutes (adjustable) every 60 minute period (adjustable). Exhaust air continues to run though the core during this time to remove frost buildup.
3. The ERV core shall transfer both sensible and latent energy between the incoming fresh air stream and the exhaust stale air stream.
4. The ERV core shall be in either a cross-flow or counter cross-flow orientation and have no moving parts.
5. The ERV core shall be certified by AHRI under its Standard 1060 for Energy Recovery Ventilators. Products not currently AHRI certified will not be accepted.
6. The ERV core shall achieve the minimum effectiveness value as indicated in the schedule.
7. The fresh air stream must have complete separation from the stale air stream to prevent cross contamination.
8. The ERV core shall have Exhaust Air Transport Ratio of 0.5% as tested to AHRI 1060 (EATR) to prevent cross-over of gases, contaminants or odors.
9. The ERV core's Outdoor Air Correction Factor (OACF) shall not exceed 1.0 as tested to AHRI 1060 (OACF) Standard.
10. The ERV core shall not be degraded or promote the growth of mold and bacteria with a rating of zero in testing according to ISO846 A and C.
11. The ERV core must be able to tolerate freezing temperatures of -30°C (-22°F and not have an increase in EATR or decrease in performance after being frozen.
12. The ERV core must be able to tolerate high temperatures of +60°C and not have an increase in EATR or decrease in performance at these elevated temperatures.
13. The ERV core must be freeze tolerant tested to 40 freeze thaw cycles from -20¬o C to +20o C while maintaining the energy recovery effectiveness and EATR rating of 0.5%.
14. The ERV core must be water washable to remove dust and contaminants.
15. The ERV core must be flame proof and comply with UL 723 with a flame spread index that shall not be over 25 and a smoke index that shall not be over 50.
16. The ERV cores should have particulate filters positioned before the incoming air streams.
17. Accepted manufacturer: CORE Energy Recovery Solutions or approved equal, subject to compliance with requirements

F. EXHAUST FAN

1. Exhaust fan shall be a single width, single inlet (SWSI) airfoil centrifugal fan. The fan wheel shall be Class II construction with aluminum fan blades that are continuously welded to the hub plate and end rim. The exhaust fan shall be a direct drive fan mounted to the motor shaft. Belts and sheaves are not acceptable due to the additional maintenance.
2. The fan motor shall be a totally enclosed EC motor that is speed controlled by the rooftop unit controller. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase. Motors shall be premium efficiency.
3. The unit DDC controller shall provide building static pressure control. The unit controller shall provide proportional control of the exhaust fans from 25% to 100% of the supply air fan designed airflow to maintain the adjustable building pressure setpoint. The field shall mount the required sensing tubing from the building to the factory mounted building static pressure sensor.

G. FILTERS

1. Unit shall be provided with a draw-through filter section. The filter rack shall be designed to accept a 2” prefilter and a 4” final filter. The unit design shall have a hinged access door for the filter section. The manufacturer shall ship the rooftop unit with 2” MERV 8 construction filters. The contractor shall furnish and install, at building occupancy, the final set of filters per the contract documents.

H. COOLING COIL

1. The indoor coil section shall be installed in a draw through configuration, upstream of the supply air fan. The coil section shall be complete with a factory piped cooling coil and an ASHRAE 62.1 compliant double sloped drain pan.
2. The direct expansion (DX) cooling coils shall be fabricated of seamless high efficiency copper tubing that is mechanically expanded into high efficiency aluminum plate fins. Coils shall be a multi-row, staggered tube design with a minimum of 3 rows. All cooling coils shall have an interlaced coil circuiting that keeps the full coil face active at all load conditions. All coils shall be factory leak tested with high pressure air under water.
3. The cooling coil shall have an electronic controlled expansion valve. The unit controller shall control the expansion valve to maintain liquid subcooling and the superheat of the refrigerant system.
4. The refrigerant suction lines shall be fully insulated from the expansion valve to the compressors.
5. The drain pan shall be stainless steel and positively sloped. The slope of the drain pan shall be in two directions and comply with ASHRAE Standard 62.1. The drain pan shall have a minimum slope of 1/8" per foot to provide positive draining. The drain pan shall extend beyond the leaving side of the coil. The drain pan shall have a threaded drain connection extending through the unit base.

I. HOT GAS REHEAT

1. Unit shall be equipped with a fully modulating hot gas reheat coil with hot gas coming from the unit condenser
2. Hot gas reheat coil shall be a Micro Channel design. The aluminum tube shall be a micro channel design with high efficiency aluminum fins. Fins shall be brazed to the tubing for a direct bond. The capacity of the reheat coil shall allow for a 20°F temperature rise at all operating conditions.
3. The modulating hot gas reheat systems shall allow for independent control of the cooling coil leaving air temperature and the reheat coil leaving air temperature. The cooling coil and reheat coil leaving air temperature setpoints shall be adjustable through the unit controller. During the dehumidification cycle the unit shall be capable of 100% of the cooling capacity. The hot gas reheat coil shall provide discharge temperature control within +/- 2°F.
4. Each coil shall be factory leak tested with high-pressure air under water.

J. SUPPLY FAN

1. Supply fan shall be a single width, single inlet (SWSI) airfoil centrifugal fan. The fan wheel shall be Class II construction with fan blades that are continuously welded to the hub plate and end rim. The supply fan shall be a direct drive fan mounted to the motor shaft. Belts and sheaves are not acceptable due to the additonal maintenance.
2. All fan assemblies shall be statically and dynamically balanced at the factory, including a final trim balance, prior to shipment.
3. Supply fan and motor assembly combinations larger than 8 hp or 22” diameter shall be internally isolated on 1” deflection, spring isolators and include removable shipping tie downs.
4. The fan motor shall be a totally enclosed EC motor that is speed controlled by the rooftop unit controller. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase. Motors shall be premium efficiency.
5. The supply fan shall be capable of airflow modulation from 30% to 100% of the scheduled designed airflow. The fan shall not operate in a state of surge at any point within the modulation range.

K. HEATING SECTION

1. The rooftop unit shall include a natural gas heating section. The gas furnace design shall be one natural gas fired heating module factory installed downstream of the supply air fan in the heat section. The heating module shall be a tubular design with in-shot gas burners.
2. The module shall be complete with furnace controller and control valve capable of 10:1 modulating operation.
3. The heat exchanger tubes shall be constructed of
4. The module shall have an induced draft fan that will maintain a negative pressure in the heat exchanger tubes for the removal of the flue gases.

5. Each burner module shall have two flame roll-out safety protection switches and a high temperature limit switch that will shut the gas valve off upon detection of improper burner manifold operation. The induced draft fan shall have an airflow safety switch that will prevent the heating module from turning on in the event of no airflow in the flue chamber.
6. The factory-installed DDC unit control system shall control the gas heat module. Field installed heating modules shall require a field ETL certification. The manufacturer's rooftop unit ETL certification shall cover the complete unit including the gas heating modules.

L. CONDENSING SECTION

1. Outdoor coils shall be cast aluminum, micro-channel coils. Plate fins shall be protected and brazed between adjoining flat tubes such that they shall not extend outside the tubes. A sub-cooling coil shall be an integral part of the main outdoor air coil. Each outdoor air coil shall be factory leak tested with high-pressure air under water.
2. Outdoor air coils shall be protected from incidental contact to coil fins by a coil guard. Coil guard shall be constructed of cross wire welded steel with PVC coating.
3. Fan motors shall be an ECM type motor for proportional control. The unit controller shall proportionally control the speed of the condenser fan motors to maintain the head pressure of the refrigerant circuit from ambient condition of 25~120°F. Mechanical cooling shall be provided to 25º F. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase.
4. The condenser fan shall be low noise blade design. Fan blade design shall be a dynamic profile for low tip speed. Fan blade shall be of a composite material.
5. The unit shall have scroll compressors. One of the compressors shall be an inverter compressor providing proportional control. The unit controller shall control the speed of the compressor to maintain the discharge air temperature. The inverter compressor shall have a separate oil pump and an oil separator for each compressor that routes oil back to the compressor instead of through the discharge line.
6. Pressure transducers shall be provided for the suction pressure and head pressure. Temperature sensor shall be provided for the suction temperature and the refrigerant discharge temperature of the compressors. All of the above devices shall be an input to the unit controller and the values be displayed at the unit controller.
7. Refrigerant circuit shall have a bypass valve between the suction and discharge refrigerant lines for low head pressure compressor starting and increased compressor reliability. When there is a call for mechanical cooling the bypass valve shall open to equalizing the suction and discharge pressures. When pressures are equalized the bypass valve shall close and the compressor shall be allowed to start.
8. Each circuit shall be dehydrated and factory charged with R-410A Refrigerant and oil.

M. ELECTRICAL

1. Unit wiring shall comply with NEC requirements and with all applicable UL standards. All electrical components shall be UL recognized where applicable. All wiring and electrical

components provided with the unit shall be number and color-coded and labeled according to the electrical diagram provided for easy identification. The unit shall be provided with a factory wired weatherproof control panel. Unit shall have a single point power terminal block for main power connection. A terminal board shall be provided for low voltage control wiring. Branch short circuit protection, 115-volt control circuit transformer and fuse, system switches, and a high temperature sensor shall also be provided with the unit. Each compressor and condenser fan motor shall be furnished with contactors and inherent thermal overload protection. Supply fan motors shall have contactors and external overload protection. Knockouts shall be provided in the bottom of the main control panels for field wiring entrance.

2. A single non-fused disconnect switch shall be provided for disconnecting electrical power at the unit. Disconnect switches shall be mounted internally to the control panel and operated by an externally mounted handle.

N. CONTROLS

1. Provide a complete integrated microprocessor based Direct Digital Control (DDC) system to control all unit functions including temperature control, scheduling, monitoring, unit safety protection, including compressor minimum run and minimum off times, and diagnostics. This system shall consist of all required temperature sensors, pressure sensors, controller and keypad/display operator interface. All MCBs and sensors shall be factory mounted, wired and tested.
2. The stand-alone DDC controllers shall not be dependent on communications with any on-site or remote PC or master control panel for proper unit operation. The microprocessor shall maintain existing set points and operate stand alone if the unit loses either direct connect or network communications. The microprocessor memory shall be protected from voltage fluctuations as well as any extended power failures. All factory and user set schedules and control points shall be maintained in nonvolatile memory. No settings shall be lost, even during extended power shutdowns.
3. The DDC control system shall permit starting and stopping of the unit locally or remotely. The control system shall be capable of providing a remote alarm indication. The unit control system shall provide for outside air damper actuation, emergency shutdown, remote heat enable/disable, remote cool enable/disable, heat indication, cool indication, and fan operation.
4. All digital inputs and outputs shall be protected against damage from transients or incorrect voltages. All field wiring shall be terminated at a separate, clearly marked terminal strip.
5. The DDC controller shall have a built-in time schedule. The schedule shall be programmable from the unit keypad interface. The schedule shall be maintained in nonvolatile memory to insure that it is not lost during a power failure. There shall be one start/stop per day and a separate holiday schedule. The controller shall accept up to sixteen holidays each with up to a 5-day duration. Each unit shall also have the ability to accept a time schedule via BAS network communications.
6. The keypad interface shall allow convenient navigation and access to all control functions. The unit keypad/display character format shall be 4 lines x 20 characters. All control settings shall be password protected against unauthorized changes. For ease of service, the display format shall be English language readout. Coded formats with look-

up tables will not be accepted. The user interaction with the display shall provide the following information as a minimum:

a. Return air temperature.
b. Discharge air temperature.
c. Outdoor air temperature.
d. Space air temperature.
e. Outdoor enthalpy, high/low.
f. Compressor suction temperature and pressure
g. Compressor head pressure and temperature
h. Expansion valve position
i. Condenser fan speed
j. Inverter compressor speed
k. Dirty filter indication.
l. Airflow verification.
m. Cooling status.
n. Control temperature (Changeover).
o. VAV box output status.
p. Cooling status/capacity.
q. Unit status.
r. All time schedules.
s. Active alarms with time and date.
t. Previous alarms with time and date.
u. Optimal start
v. Supply fan and exhaust fan speed.
w. System operating hours.

1) Fan
2) Exhaust fan
3) Cooling
4) Individual compressor
5) Heating
6) Economizer
7) Tenant override

7. The user interaction with the keypad shall provide the following:

a. Controls mode

1) Off manual
2) Auto
3) Heat/Cool
4) Cool only
5) Heat only
6) Fan only

b. Occupancy mode

1) Auto
2) Occupied
3) Unoccupied
4) Tenant override

c. Unit operation changeover control

1) Return air temperature
2) Space temperature
3) Network signal

d. Cooling and heating change-over temperature with deadband
e. Cooling discharge air temperature (DAT)
f. Supply reset options

1) Return air temperature
2) Outdoor air temperature
3) Space temperature
4) Airflow (VAV)
5) Network signal
6) External (0-10 vdc)
7) External (0-20 mA)

g. Temperature alarm limits

1) High supply air temperature
2) Low supply air temperature
3) High return air temperature

h. Lockout control for compressors.
i. Compressor interstage timers
j. Night setback and setup space temperature.
k. Building static pressure.
l. Economizer changeover
m. Enthalpy

1) Drybulb temperature
2) Currently time and date

n. Tenant override time
o. Occupied/unoccupied time schedule
p. One event schedule
q. Holiday dates and duration

r. Adjustable set points
s. Service mode

1) Timers normal (all time delays normal)
2) Timers fast (all time delays 20 sec)

8. If the unit is to be programmed with a night setback or setup function, an optional space sensor shall be provided. Space sensors shall be available to support field selectable features. Sensor options shall include:

a. Zone sensor with tenant override switch
b. Zone sensor with tenant override switch plus heating and cooling set point adjustment. (Space Comfort Control systems only)

9. To increase the efficiency of the cooling system the DDC controller shall include a discharge air temperature reset program for part load operating conditions. The discharge air temperature shall be controlled between a minimum and a maximum discharge air temperature (DAT) based on one of the following inputs:

a. Airflow
b. Outside air temperature
c. Space temperature
d. Return air temperature
e. External signal of 1-5 vdc
f. External signal of 0-20 mA
g. Network signal

3. EXECUTION

3.1 EXAMINATION

A. Verification of existing conditions prior to beginning work.

B. Verify that roof is ready to receive work and opening dimensions are as indicated on shop drawings.

C. Verify that proper power supply is available.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NFPA 90A.

C. Mount units on factory-built roof mounting curb providing watertight enclosure to protect ductwork and utility services. Install roof mounting curb level.

3.3 MANUFACTURER'S FIELD SERVICES

A. Provide initial start-up and shut-down during first year of operation, including routine servicing and check-out.

3.4 Provide services of factory trained representative for start-up, leak test, refrigerant pressure test, evacuate, dehydrate, charge, start-up, calibrate controls, and instruct.

3.5 WARRANTY

A. Entire unit to have a complete 1 year parts and labor warranty following date of substantial completion. Provide an extended 5 year parts and labor warranty on the integral controls and all components of the refrigerant circuits system including compressors

END OF SECTION

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SECTION 23 81 26 – SPLIT SYSTEMS

1. GENERAL

1.1 SECTION INCLUDES

A. Ductless split system with outdoor condensing units and indoor fan coil unit.

1.2 RELATED SECTIONS

A. Section 23 05 13 – Electrical Requirements for Mechanical Equipment.

B. Section 23 05 93 – Testing, Adjusting and Balancing.

1.3 REFERENCES

A. ARI 210 - Unitary Air-Conditioning Equipment.

B. ARI 240 - Unitary Air-Conditioning Equipment.

C. ARI 270 - Sound Rating of Outdoor Unitary Equipment.

D. ASHRAE 15 - Safety Code for Mechanical Refrigeration.

E. IECC and ASHRAE 90.1 - Energy Conservation in new Building Design.

1.4 SUBMITTALS FOR REVIEW

A. Reference section 23 05 00.

B. Shop Drawings: Indicate components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections. Include schematic layouts showing condensing units, cooling coils, refrigerant piping, and accessories required for complete system.

C. Product Data: Provide rated capacities, weights specialties and accessories, electrical nameplate data, and wiring diagrams.

1.5 SUBMITTALS AT PROJECT CLOSEOUT

A. Reference section 23 05 00.

B. Operation and Maintenance Data: Include start-up instructions, maintenance instructions, parts lists, controls, and accessories.

1.6 QUALITY ASSURANCE

A. Unit will be rated in accordance with the latest edition of ARI Standard 210.

B. Unit will be certified for capacity and efficiency, and listed in the latest ARI directory.

C. Unit construction will comply with latest edition of ANSI/ ASHRAE and with NEC.

D. Unit will be constructed in accordance with UL standards and will carry the UL label of approval.

E. Unit will have UL approval.

F. Unit cabinet will be capable of withstanding Federal Test Method Standard No. 141 (Method 6061) 500-hr salt spray test.

G. Air-cooled heat pump and cooling coil condenser coils will be leak tested at 150 psig and pressure tested at 450 psig.

1.7 Unit constructed in ISO 9001 approved facility

1.8 DELIVERY, STORAGE, AND PROTECTION

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Protect units on site from physical damage. Protect coils.

1.9 WARRANTY

A. Warranties

B. Provide a five year warranty to include coverage for refrigerant compressors.

2. PRODUCTS

2.1 DUCTLESS SPLIT SYSTEM

A. Indoor, wall-mounted, direct-expansion fan coil shall be matched with the commercial condensing units.

B. Unit shall be rated per ARI Standards 210 and listed in the ARI directory as a matched system.

C. Indoor, direct-expansion, wall-mounted fan coil. Unit shall be complete with cooling coil, fan, fan motor, piping connectors, electrical controls, microprocessor control system, and integral temperature sensing. Unit shall be furnished with integral wall-mounting bracket and mounting hardware, and thermistor interconnection cable.

1. Unit Cabinet: Cabinet discharge and inlet grilles shall be attractively styled, high-impact polystyrene. Cabinet shall be fully insulated for improved thermal and acoustic performance.
2. Fans: Fan shall be tangential direct-drive blower type with air intake at the upper front face of the unit and discharge at the bottom front. Automatic, motor-driven vertical air sweep shall be provided standard air sweep operation shall be user selectable. Horizontal direction may be manually adjusted (using remote controller) and vertical air sweep may be manually set.
3. Coil: Coil shall be copper tube with aluminum fins and galvanized steel tube sheets. Fins shall be bonded to the tubes by mechanical expansion. A drip pan under the coil shall have a drain connection for hose attachment to remove condensate. Condensate pan shall have internal trap and auxiliary drip pan under coil header.
4. Motors: Motors shall be open drip-proof, permanently lubricated ball bearing with inherent overload protection. Fan motors shall be 3-speed.
5. Controls: Controls shall consist of a microprocessor-based control system which shall control space temperature, determine optimum fan speed, and run self diagnostics. The temperature control range shall be from 64 F to 84 F. The unit shall have the following functions as a minimum.

    a. An automatic restart after power failure at the same operating conditions as at failure.
    b. A timer function to provide a minimum 24-hour timer cycle for system Auto. Start/Stop.
    c. Temperature-sensing controls shall sense return-air temperature. Indoor-air high discharge temperature shutdown shall be provided.
    d. Indoor coil freeze protection.
    e. Wired controller to enter set points and operating conditions.
    f. Auto Stop features shall have integral setback control.
    g. Automatic airsweep control to provide on or off activation of airsweep louvers.
    h. Dehumidification mode shall provide increased latent removal capability by modulating system operation and set point temperature.
    i. Fan only operation shall provide room air circulation when no cooling is required.

j. Diagnostics shall provide continuous checks of unit operation and warn of possible malfunctions. Error messages shall be displayed at the unit and at the remote controller.
k. An indoor to outdoor thermistor connection cable shall be provided with the fan coil unit.
l. Fan speed control shall be user-selectable: high, medium, low, or microprocessor automatic operation during all operating modes.
m. A time delay shall prevent compressor restart in less than 3 minutes.
n. Automatic heating-to cooling changeover to provide automatic heating and cooling operation. Control shall include deadband to prevent rapid mode cycling.
o. Demand defrost shall be provided and shall minimize defrost cycles by internally adjusting defrost timing based on frost accumulation.
p. Indoor coil high temperature protection shall be provided to detect excessive indoor discharge temperature when unit is in heat pump mode.

6. Filters: Unit shall have filter track with factory-supplied cleanable filters.
7. Electrical Requirements: Refer to the schedule for electrical requirements. Power and control connections shall have terminal block connections.
8. Operating Characteristics: Refer to schedule for performance requirements.

D. Commercial Condensing Units

1. Outdoor-mounted, air-cooled split system outdoor section suitable for rooftop installation.
2. Unit shall consist of a hermetic or rotary compressor, an air-cooled coil, propeller-type blow-thru outdoor fans, accumulator, full refrigerant charge, and control box. Unit shall discharge air horizontally as shown on the contract drawings. Units shall function as the outdoor component of an air-to air cooling system.
3. Units shall be used in a refrigeration circuit matched to a duct-free cooling fan coil unit.
4. Unit construction shall comply with ANSI/ASHRAE 15, latest revision, and with the NEC. Units shall be constructed in accordance with UL standards. Units shall be listed in the CEC directory. Unit cabinet shall be capable of withstanding Federal Test Standard No. 141 (method 6061) 500-hour salt spray test.
5. Air-cooled condenser coils shall be leak tested for R-410A operating pressures with the coil submerged in water.
6. Factory assembled, single piece, air-cooled outdoor unit. Contained within the unit enclosure shall be all factory wiring, piping, controls, compressor, full charge of R-410A refrigerant, and special features required prior to field start-up.
7. Unit Cabinet: Unit cabinet shall be constructed of galvanized steel, bonderized and coated with a baked-enamel finish.
8. Unit access panels shall be removable with minimal screws and shall provide full access to the compressor, fan, and control components.
9. Outdoor compartment shall be isolated and have an acoustic lining to assure quiet operation.
10. Fans: Outdoor fans shall be direct-drive propeller type, and shall discharge air horizontally. Fans shall blow air through the outdoor coil.
11. Outdoor fan motors shall be totally enclosed; single-phase motors with class B insulation and permanently lubricated sleeve bearings. Motor shall be protected by internal thermal overload protection.

12. Shaft shall have inherent corrosion resistance.
13. Fan blades shall be corrosion resistant and shall be statically and dynamically balanced.
14. Outdoor fan openings shall be equipped with PVC coated protection grille over fan and coil.
15. Compressor: Compressor shall be fully hermetic reciprocation or scroll type.
16. Compressor shall be equipped with oil system, operating oil charge, and motor. Internal overloads shall protect the compressor from overtemperature and overcurrent. Scroll compressors shall also have high discharge gas temperature protection if required.
17. Motor shall be NEMA rated class F, suitable for operation in a refrigerant atmosphere.
18. Reciprocating compressors shall be equipped with crankcase heaters to minimize liquid refrigerant accumulation in compressor during shutdown and to prevent refrigerant dilution of oil.
19. Compressor assembly shall be installed on rubber vibration isolators and shall have internal spring isolation. Compressors shall be single-phase or 3-phase as specified on the contract drawings.
20. Outdoor Coil: Coil shall be constructed of aluminum fins mechanically bonded to internally enhanced, seamless copper tubes, which are cleaned, dehydrated, and sealed.
21. Refrigeration Components: Refrigerant circuit components shall include brass external liquid line service valve with service gage port connections, suction line service valve with service gage connection port, service gage port connections on compressor suction and discharge lines with Schrader type fittings with brass caps, accumulator, pressure relief, and a full charge of refrigerant.
22. Controls and Safeties: Operating controls and safeties shall be factory selected, assembled, and tested. The minimum control shall include the following:

    a. Time delay restart to prevent compressor reverse rotation on single-phase scroll compressors.
    b. Automatic restart on power failure.
    c. Safety lockout if any outdoor unit safety is open.
    d. A time delay control sequence provided through the fan coil board, thermostat, or controller.
    e. High-pressure and liquid line low-pressure switches.
    f. Liquid line low-pressure switches.
    g. Automatic outdoor-fan motor protection.

23. Start capacitor and relay (single-phase units without scroll compressors).
24. The minimum safeties shall include the following:

    a. System diagnostics.
    b. Compressor motor current and temperature overload protection.
    c. High-pressure relief.
    d. Outdoor fan failure protection.

25. Electrical Requirements: Refer to schedule for electrical requirements. Unit electrical power shall be a single point connection. All power and control wiring must be installed per NEC and all local building codes. High and low voltage terminal block connections.
26. Special Features:

a. Low-Ambient Kit: Control shall regulate fan-motor cycles in reponses to saturated condensing, pressure of the unit. The control shall be capable of maintaining a condensing temperature of 100 F ± 10 F with outdoor temperatures to –20 F. Installation of kit shall not require changing the outdoor-fan motor.
b. Winter Start Control: Field supplied and installed winter start control shall permit start-up for cooling operation under low-load conditions and at low-ambient temperatures by bypassing the low-pressure switch for a 3-minute delay period.
c. Crankcase Heater (units with scroll compressors only):
d. Unit shall be shipped with a clamp-on compressor oil sump heater.
e. Hard Start Kit: Field installed accessory start capacitor and start relay shall give a hard boost to compressor motor at each start.
f. Wind Baffle Kit: Shall be fabricated sheet metal wrapper used to provide improved unit operation during high winds.

3. EXECUTION

3.1 EXAMINATION

A. Verify that required utilities are available, in proper location, and ready for use.

B. Beginning of installation means installer accepts existing surfaces.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Protect units with protective covers during balance of construction.

C. Complete structural, mechanical, and electrical connections in accordance with manufacturer's installation instructions.

D. Provide for connection to electrical service.

E. Provide connection to refrigeration piping system and evaporators. Refer to Section 232300. Comply with ASHRAE 15.

F. Furnish charge of refrigerant and oil.

3.3 CLEANING

A. After construction is completed, 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, using finish materials furnished by manufacturer.

C. Install new filters.

3.4 DEMONSTRATION AND INSTRUCTIONS

A. Section 23 05 00 demonstrating installed work.

B. Supply initial charge of refrigerant and oil for each refrigeration system. Replace losses of oil or refrigerant prior to end of correction period.

C. Charge system with refrigerant and test entire system for leaks after completion of installation. Repair leaks, put system into operation, and test equipment performance.

D. Shut-down system if initial start-up and testing takes place in winter and machines are to remain inoperative. Repeat start-up and testing operation at beginning of first cooling season.

E. Provide cooling season start-up, and winter season shut-down for first year of operation.

F. Inspect and test for refrigerant leaks every three months during first year of operation.

END OF SECTION

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SECTION 23 84 13 - HUMIDIFIERS

1. GENERAL

1.1 SECTION INCLUDES

A. Gas-fired steam humidification system.

1.2 REFERENCES AND REGULATORY REQUIREMENTS

A. See Section 23 05 00.

B. Certifications:

1. CE – Gas Appliance Regulation (GAR), LVD, EMC
2. CSA/AGA/CGA ETL
3. SCAQMD 1146.2 for low Nox

1.3 SUBMITTALS

A. See Section 23 05 00.

1. Comply with submittal procedures and execution and closeout requirements in this section.
2. Submit product data (manufacturer's specifications and technical data including performance, construction, and fabrication) for each manufactured component.

1.4 Warranty

A. Product shall be warranted to be free from defects in materials and fabrication for a period of two years after installation or 27 months from manufacturer ship date, whichever date is the earlier.

1.5 OPERATION AND MAINTENANCE DATA

A. See Section 23 05 00.

1.6 QUALIFICATIONS

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

1.7 DELIVERY, STORAGE AND HANDLING

A. See Section 23 05 00.

1.8 SEQUENCING AND SCHEDULING

A. See Section 23 05 00.

2. PRODUCTS

2.1 HUMIDIFICATION SYSTEM

A. System: Humidification system shall include a steam generator, steam dispersion assembly, control equipment, and accessories.

B. Steam generator: Steam generator shall be by a gas-to-steam evaporative steam humidifier manufactured by Dri-Steem or equal meeting the specifications here within.

C. Fabrication requirements:

1. Tank and primary heat exchanger: 14-gauge 304-stainless steel with water side welded seams for all water-submerged welds.
2. Humidifier shall include a 316 stainless steel secondary heat exchanger to pre-heat inlet water and combustion air using exhaust gasses exiting the primary heat exchanger.
3. Tank bottom shall be slanted with drain port at bottom of tank to ensure complete draining.
4. Steam outlet on top of tank configured to connect to hose and pipe (NPT or BSP connection) for units up to 150 lbs/hr, and only pipe (NPT, BSP, or flange connection) for units from 200 lbs/hr to 600 lbs/hr.
5. Humidifier must be designed and approved by manufacturer to safely operate with PVC flue venting.
6. Unit shall include adaptable fittings to utilize PVC, CPVC, polypropylene inlet and flue venting material as required by local codes.
7. Include removable cover allowing easy access to water sensing assembly in the tank.
8. Tank shall have an easily accessible cleanout plate.
9. Indoor humidifier shall have a painted aluminum enclosure to protect all humidifier components and have an integral base with openings designed for moving humidifier with a forklift or pallet jack.
10. Humidifier tank shall be insulated with 1/2"-thick (12.5 mm), K-Flex closed cell insulation.
11. Units shall be capable of fitting through a 36" (91 mm) wide door.
12. Humidifier shall have sealed combustion plumbed to the unit shroud.
13. Tank and primary heat exchanger shall be 316 stainless steel with water side welded seams for all water-submerged welds.

D. Water type, fill, and drain requirements:

1. Water type: Humidifier shall be capable of generating steam from RO water.

2. The humidifier shall not require changes to controls or components in the field due to changes in the water type.
3. The humidifier shall sense water purity and automatically adjust drain rates accordingly to minimize tank maintenance and optimize water usage.
4. Fill and drain line piping shall include anti-siphoning mechanisms that prevent tank siphoning and potential inlet water contamination.
5. Humidifier shall incorporate a water surface skimming feature to drain away water surface debris and contaminants to minimize tank cleaning maintenance and risk of foaming.
6. An electric drive valve shall be mounted on humidifier assembly to allow tank to drain automatically at the end of a humidification season.

    a. Provide complete tank draining with no standing water.
    b. Minimum 5 gpm flow rate for fast draining.
    c. The system shall monitor drain water temperature with temperature viewable on the unit's display.

7. Integral water tempering control shall meter cold water at the drain in order to temper 212°F (100°C) water to a maximum 140°F (60°C) discharge temperature at full drain rate to sanitary system during normal operation.

    a. Drain water tempering shall employ closed loop feedback using the drain temperature sensor to automatically control the drain and fill valves. Drain water temperature shall not exceed 140 °F (60 °C) while system shall minimize (cold) water usage by not excessively tempering.
    b. Minimize drain and refill time by sensing when water is no longer draining (tank empty) to quickly initialize refilling of tank and subsequent re-start of humidification.

E. Burner assembly:

    a. Humidifier and burner assembly shall be CSA/AGA/CGA/ETL certified and tested to support natural gas or LP gas.
    b. Gas train assembly shall be complete with burner/mixing tube assembly, igniter, sight glass, flame rod electrode, gas manifold, integral gas valve and venturi.
    c. Each burner shall freely modulate with a gas input turndown ratio of at least 5:1.

F. Humidifier performance:

    a. Unit shall be of a condensing design utilizing a secondary heat exchanger to achieve average thermal efficiencies of over 93%.
    b. The high-efficiency humidifier shall be certified by South Coast Air Quality Management District (SCAQMD) to meet low NOx requirements of Rule 1146.2.

G. Markings showing certifications, electrical warnings, and connections to gas, vent, combustion air, water supply and drain shall be on unit.

H. Internal water tempering device: A factory-installed thermostatically controlled water valve shall meter an amount of cold water into a stainless steel mixing chamber to temper 212 deg F water with a 6 gpm in-flow rate to a 140 deg F discharge temperature to sanitary system.

I. Unit shall automatically perform a tempered drain upon power interruption using a normally open drain valve and thermostatically controlled valve.

J. Humidifier Controls:

1. Control subpanel: Control subpanel shall be factory-attached to humidifier with all wiring between subpanel and humidifier completed at factory. A wiring diagram shall be included.
2. Vapor-logic microprocessor controller with the following features or functions:

    a. Touchscreen user interface shall be included standard on all models

        1) Minimum 5” (125 mm) diagonal 800 x 480 24 bit RGB color display
        2) Touch-sensitive screen control including swipe-scrolling of lists
        3) Display operable within a temperature range of 32 to 158 °F (0 to 70 °C)
        4) Animated graphical display of humidifier operating conditions
        5) Icon-based function keys on screen with consistent Home option to facilitate navigation
        6) Setup wizard, context-sensitive Help screens and output test functions for unit commissioning
        7) On-screen QR Code links to humidifier installation literature
        8) Prioritized color-coded alerts with time & date of occurrence, including log of up to 60 prior event messages.
        9) Unit name information; editable with full qwerty on-screen keyboard.
        10) Adjacent four-color LED status light of humidifier operating condition

    b. Web interface and server, included standard on all models:

        1) Web interface shall have same functionality as Vapor-logic touchscreen display
        2) Web interface shall allow multiple remotely located users to simultaneously view system operation and/or change system parameters.
        3) Web interface shall have password-protected secure access.
        4) Web interface shall be compatible with standard Internet browsers.
        5) Web interface shall connect directly to a personal computer or through a system network via Ethernet cable.

3. Touchscreen display shall be factory mounted on humidifier.
4. Controller shall provide redundant tank over-temperature and flue over-temperature safety control using inputs from the tank temperature sensor and flue temperature sensor.

5. Humidifier shall have tank over-temperature switch and flue over-temperature switch operating independently of the tank temperature sensor and flue temperature sensor.
6. Include flue temperature sensing to temporarily reduce humidifier output if flue temperatures approach maximum, and to disable unit should maximum flue temperature be reached.
7. Controller shall provide fully modulating control of humidifier capacity.
8. Controller shall provide PID control capability with field-adjustable settings.
9. Water level control:

    a. Automatic refill, low water cutoff, surface skimming and automatic drain-down of humidifier. System shall consist of:

        1) A water level sensing unit comprised of three metallic probes mounted in probe head. Probe head shall incorporate probe isolation chamber to eliminate fouling caused by mineral coatings.
        2) Fill valve assemblies factory mounted on the humidifier assembly.
        3) End-of-season drain automatically drains humidifier tank after a user-defined period of system inactivity.

10. Tank temperature sensor: A factory mounted sensor, with a temperature range of -40 to 248 °F (-40 to 120 °C) mounted on the humidifier to enable the following functions:

    a. Maintain the evaporating chamber water temperature above freezing
    b. Maintain a user-defined preset evaporating chamber water temperature
    c. Allow rapid warm-up of water in evaporating chamber after a call for humidity, providing 100% operation until steam production occurs

11. USB port on the control board and touchscreen for software updates, data backups, and data restoration.
12. Up-time optimizer function to keep humidifier(s) operating through conditions such as fill, drain, or run-time faults, as long as safety conditions are met, minimizing production down-time.
13. Real-time clock to allow time-stamped alarm/message tracking, and scheduled events.
14. Factory commissioning of humidifier and control board, including system configuration as-ordered, factory unit testing, and operation with water before shipping.
15. Alarms, unit configuration, and usage timer values shall remain in nonvolatile memory indefinitely during a power outage.
16. The capability to monitor, control, and/or adjust the following parameters:

    a. Relative humidity (RH) set point, actual conditions in the space (from humidity transmitter), RH offset
    b. Dew point set point, actual conditions in the space (from dew point transmitter), dew point offset
    c. Relative humidity (RH) duct high limit set point (switch) and actual conditions
    d. Relative humidity (RH) duct high limit set point, actual conditions (from transmitter), high limit span, and high limit offset

e. Total system demand in % of humidifier capacity
f. Total system output in lbs/hour (kg/h)
g. Drain/flush duration, allowed days, and frequency based on usage.
h. End-of-season drain status and hours humidifier is idle before end of season draining occurs
i. Window glass surface temperature (in % RH offset application using sensor ordered as an option) with programmable offset
j. Air temperature or other auxiliary temperature monitoring with programmable offset (using sensor ordered as an option)
k. System alarms and system messages, current and previous
l. Adjustable water skim duration
m. Programmable outputs for remote signaling of alarms and/or messages, device activation (such as a fan), or for signaling tank heating and/or steam production
n. System diagnostics that include:

1) Test outputs function to verify component operation
2) Test humidifier function, by simulating demand to validate performance
3) Data collection of RH, water use, energy use, alarms, and service messages for download to USB.

o. Password-protected system parameters
p. Touchscreen display or Web interface displays in English, French, Spanish, Dutch or German languages
q. Numerical units displayed in inch-pound or SI units

17. Interoperability using BACnet MS/TP or BACnet IP.
18. Control input accessory options:

a. Humidity transmitter, duct: Humidity transmitter shall be a duct-mounted device that measures from 0% to 100% RH range and provides a linear output (10% to 90% RH) from 4 to 20 mA. Accuracy ± 2% RH. Supply voltage 21 VDC. Operating temperature range: -4 to 140 °F (-20 to 60 °C).
b. Humidistat, on-off, high limit: Electric humidistat control shall be an on-off style, duct mounted with a control range of 15% to 95% RH. Compatible with 24, 120, and 240 VAC. Operating temperature range 40 to 125 °F (4 to 52 °C).
c. Airflow proving switch, pressure type: Airflow proving switch shall be diaphragm-operated with pitot tube for field installation. Switch shall have an adjustable control point range of 0.05" to 12" wc (12.5 to 2988 Pa) Operating temperature range -40 to 180 °F (-40 to 82 °C). Compatible with 24, 120, and 240 VAC.

K. Humidifier accessories

1. Condensate neutralizer: Flue condensate is acidic with a 2-4 pH range. Provide a condensate neutralizer to treat condensate that forms in flue piping and the humidifier's secondary heat exchanger. Neutralizer to contain media that neutralizes the condensate water, raising the pH to near neutral. The neutralizer shall be piped so to drain both flue

and heat exchanger condensate to the neutralizer inlet. Drain piping to and from neutralizer shall be unrestrictive to prevent condensate backup into humidifier heat exchanger. Neutralizer life shall be size to perform a minimum one year at 30% humidifier run hours, to be replaced when discharge condensate pH fall below 5.0.

L. Humidification dispersion: Humidification steam shall be dispersed by DriSteem Ultra-sorb Model LV Steam Dispersion Panel or equal meeting specifications here within:

1. Performance: Dispersion assembly shall disperse evaporative, non-pressurized humidification steam into ducted or open spaces.
2. High-efficiency dispersion:

    a. Dispersion tubes shall be insulated with a plenum-approved insulating material for in-duct installation and have an R-value not less than 0.5 at a thickness not more than 0.125" (3.2 mm), for minimal increase in dispersion tube diameter.
    b. Airstream heat gain shall not exceed the values as scheduled; the values shall be supported by the manufacturer's published data.
    c. Insulating material shall meet the following criteria at 0.125" (3.2 mm) thickness:

        1) Fire/smoke index shall be 0/0 per any of the following test procedures:

            a) UL 723 fire/smoke index (Test for Surface Burning Characteristics of Building Materials)
            b) NFPA 255 (Standard Method of Test of Surface Burning Characteristics of Building Materials)
            c) ASTM E84 (Surface Burning Characteristics for Materials Used in Plenums)

        2) Stable up to 300 °F (148 °C) continuous — to prevent material degradation, hardening, or crumbling at high temperatures
        3) Closed-cell construction that does not absorb water or support microbial growth — to negate the need for vapor barriers and jackets
        4) Non-toxic and pure as documented in manufacturer's data — to prevent off-gassing and to facilitate use in clean rooms, pharmaceutical applications, and food industries
        5) Will not degrade when exposed to UVC light — to negate the need for UV wraps
        6) Continuous, seam-welded, and held in place without bands or clamps — to minimize surfaces for the accumulation of particulate matter

3. Absorption: See schedule on drawings for required absorption distance.
4. Fabrication and components: Dispersion tube panel shall include steam dispersion tubes spanning the distance between the two headers, a steam supply header/separator, a condensate collection header, and a metal casing.

a. Dispersion tubes:

1) Each tubelet shall extend through the wall of the dispersion tube and incorporate a properly sized calibrated orifice.
2) Dispersion tubes shall have two rows of steam discharge tubelets and shall discharge steam in diametrically opposite directions perpendicular to airflow
3) Tubelets shall be constructed of high-temperature resin
4) Tubes shall be joined to headers with slip-fit couplings to facilitate easy removal.

b. Header material: Headers shall be constructed of 304 stainless steel with welded seams.

c. Dispersion panel casing:

1) Each packaged humidifier panel assembly shall be contained within a steel casing to allow convenient duct mounting, or to facilitate the stacking of and/or the end-to-end mounting of multiple humidifier panels in ducts or air handler casings.
2) Casing assembly shall be 304 stainless steel.

M. Humidification dispersion: Humidification steam shall be dispersed by DriSteem Ultra-sorb Model LV Steam Dispersion Panel or equal meeting specifications here within:

N. Piping between steam generator and humidification dispersion panel: Refer to specification section 23 21 13 Hydronic Piping.

3. EXECUTION

3.1 INSTALLATION

A. Install per manufacturer's printed instructions and as indicated on drawings. Coordinate electrical connections as specified in Division 26.

3.2 FIELD QUALITY CONTROL:

A. Start-up: Upon completion of installation of units, provide start-up by factory authorized and trained operators and operate equipment to demonstrate capability and compliance with requirements. Field correct malfunctioning units, then retest to demonstrate compliance. Manufacturer's representative shall submit a letter to the Architect/Engineer certifying the equipment is operating properly and in accordance with this specification.

3.3 TRAINING:

A. Schedule training with Owner. The manufacturer's representative and the Division 23 contractor shall be present. The training shall be coordinated by the Division 23 contractor and the Owner in conjunction with the other mechanical equipment on the project.

1. Train the Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, and servicing and preventative maintenance schedules and procedures. Review with the Owner's personnel, the contents of the Operating and Maintenance Data specified in Division 1 and Section 23 05 00.
2. Schedule training with Owner with at least seven (7) days prior notice.

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SECTION 26 05 00 - ELECTRICAL GENERAL PROVISIONS

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1-specification sections, apply to work of this Section.

1.2 DESCRIPTION OF WORK

A. The work included under this Section consists of providing all labor, materials, supervision, and construction procedures necessary for the installation of the complete electrical systems required by these specifications and/or shown on the drawings of the contract.

B. The Contract Drawings are shown in part diagrammatic intended to convey the scope of work, indicating the intended general arrangement of equipment, conduit, and outlets. Follow the drawings in laying out the work and verify spaces for the installation of the materials and equipment based on the dimensions of actual equipment furnished. Whenever a question exists as to the exact intended location of outlets or equipment, obtain instructions from the Engineer before proceeding with the work.

C. Portions of this facility (as indicated on the drawings) are classified as an animal facility/vivarium. All penetrations into the animal facility must be adequately sealed as outlined within the drawings and these specifications.

1.3 QUALITY ASSURANCE

Installers shall have at least 2 years of successful installation experience on projects with electrical installation work similar to that required by the project. All equipment and materials shall be installed in a neat and workmanlike manner and shall be aligned, leveled, and adjusted for satisfactory operation.

1.4 REFERENCES

A. The design, manufacture, testing, and method of installation of all equipment and materials furnished under the requirements of this specification shall conform to the following codes, standards and regulations, etc.:

1. Safety and Health Regulations for Construction.
2. Occupational Safety and Health Standards, National Consensus Standards and Established Federal Standards.
3. National Electrical Code (NEC).
4. American National Standards Institute (ANSI).
5. National Electric Manufacturer's Association (NEMA).
6. Institute of Electrical and Electronic Engineers (IEEE).
7. National Fire Protection Association (NFPA).

8. Insulated Cable Engineers Association (ICEA).
9. American Society for Testing and Materials (ASTM).
10. Life Safety Code NFPA #101.
11. Underwriters Laboratories, Inc. Standards (UL).
12. Factory Mutual Engineering Corporation or other recognized National Laboratories.
13. National Electrical Safety Code (NESC).

B. The latest adopted edition by the local and state inspection authorities of all standards and specifications listed above shall apply.

C. Furthermore, the electrical work shall be in accordance with all applicable National and State Standards, and Local Codes and Building Ordinances. The electrical work shall merit the approval of the enforcing authorities having jurisdiction.

1.5 MATERIALS AND EQUIPMENT

A. Electrical materials and equipment for the entire project shall meet the requirements specified under the Supplementary Conditions Section of this specification.

B. Equipment and fixtures shall be connected to provide circuit continuity in accordance with applicable Codes whether or not each piece of conductor, conduit, or protective device is shown between such items of equipment or fixtures and the point of circuit origin.

C. The electrical work includes the installation or connection of certain materials and equipment furnished by others. Verify all connection details.

D. All equipment over 50 pounds shall be provided with adequate lifting means.

2. PRODUCTS (NOT USED)

3. EXECUTION

3.1 ACCESS TO EQUIPMENT

A. Starters, switches, receptacles, pull boxes, etc. shall be located to provide easy access for operation, repair and maintenance. If the devices listed above are concealed, access doors shall be provided.

3.2 SUBMITTALS

A. Test Reports: Provide the tests as outlined in this specification and all other tests necessary to establish the adequacy, quality, safety, completed status, and suitable operation of each electrical system. Provide the Engineer with a complete schedule of all tests.

1. Ground Rod Test: Immediately after installation, test driven grounds and counterpoises with a ground resistance direct-reading single-test megger, using the AC fall-of-potential method and two reference electrodes. Orient the ground to be tested and the two reference electrodes in a straight line spaced 50 feet apart. Drive the reference

electrodes five feet deep. Disconnect the ground rod to be tested from other ground systems at the time of testing. The ground resistance for the electrical service must be 15 Ohms or less. Submit the results, date of test, and soil conditions to the Engineer in writing immediately after testing.

2. Final Tests: Start final tests after complete preliminary tests have been made which indicate adequacy, quality, completion, and satisfactory operation of all electrical systems. Included in these tests are the following:

    a. Completion of the form "Electrical Test Report" (attached to the end of this specification section) in sufficient quantity to provide the indicated information for each panelboard and switchboard in the project.
    b. Completion of the form "Motor Test Report" (attached to the end of this specification section) in sufficient quantity to provide the indicated information for all three phase motors.

3. The Contractor shall submit the above completed reports to the Engineer, noting all deviations from the requirements listed below:

    a. Plus or minus five percent variation between nominal system voltage and no load voltage, or plus or minus five percent variation between no load and full load voltage.
    b. Plus five-percent variation between rated and actual motor current.
    c. Plus or minus ten percent variation between average phase current and measured individual phase current. The Contractor shall balance phase currents of all distribution equipment within the tolerances specified.
    d. Insulation resistance between conductors and ground of not less than 1,000,000 Ohms.

4. Final Corrections: Correct promptly any failure or defects revealed by these tests as determined by the Engineer. Reconduct tests on corrected items as directed by the Engineer.

B. Operation and Maintenance Manuals: Operation and Maintenance Manuals shall be provided according to Division 1 requirements. In general, during the time of the contract, and before substantial completion of the electrical installation, submit to the Engineer the number of copies described in the Division 1 specifications and the General and Supplemental Conditions copies of descriptive literature, maintenance recommendations (from the equipment manufacturer), data on initial operation, wiring diagrams, performance curves, engineering data and tests, operating procedures, routine maintenance procedures, and parts lists for each item of electrical equipment installed under this contract and submit all manufacturer's guarantees and warranties.

C. Shop Drawings: The Contractor shall furnish shop drawing portfolios and proper transmittal forms for all materials, equipment, and lighting fixtures to be incorporated in the work in accordance with the General Conditions, Supplementary Conditions, and all other applicable Conditions.

1. Shop drawings on component items forming a system or that are interrelated shall be submitted at one time as a single submittal in order to demonstrate that the items have been properly coordinated and will function properly as a system. A notation shall be made on each shop drawing submitted as to the item's specific use, either by a particular type number referenced on the drawings or in the specifications, by a reference to the applicable paragraph of the specifications, or by a description of its specific location. The shop drawings shall be organized and bound into sets with each set collated.
2. The Engineer shall have the final authority as to whether the equipment or material submitted is equal to the specified item. Proposed substitutions may be rejected for aesthetic reasons if felt necessary or desirable. In the event the proposed substitutions are rejected, the Contractor shall furnish the specified item.

3.3 EXISTING UTILITIES

A. The Contractor shall verify the location of all existing utilities with the Owner and Utility providers prior to commencing excavation work. In addition, the contractor is responsible for locating and maintaining all existing utilities without damage. Fully coordinate all new underground utility work with existing utilities on the site The drawings and survey data of the contract documents indicate the available information on the existing power and communication services, and on new services to be provided to the project by utility provider. Accuracy of this information is not assured.

3.4 ELECTRICAL SERVICE

A. The Contractor shall provide all material and pay all fees required by the local utility provider for the connection of the new electrical service as shown on the plans. The Contractor shall also meet all equipment requirements of the local utility provider. The Contractor shall provide all necessary materials for construction of the temporary electrical service and shall coordinate all details with the local utility provider.

3.5 SMOKE AND SMOKE/FIRE DAMPERS

Provide all necessary duct detectors for smoke and smoke/fire dampers. In addition, provide all necessary connections, including power supply circuits (fed from the nearest panelboard, emergency if available, of the appropriate voltage unless indicated otherwise on the drawings) to smoke dampers and smoke/fire dampers so that upon fire alarm conditions or integral smoke detector activation, the dampers close. Coordinate damper and control locations with the mechanical and controls contractors. Refer to the mechanical drawings for damper schedule and locations.

3.6 ELECTRICAL-MECHANICAL EXTENT OF WORK

A. The responsibility of work specified under Divisions 21, 22, 23 and 26 is clarified under, Sections 21 05 00, 22 05 00 and 23 05 00. Said Sections are incorporated herein by reference.

3.7 ELECTRICAL PRODUCT COORDINATION

A. Refer to Division 2 through Division 32 and the electrical drawings for the power characteristics required and available for the operation of each power-consuming item of equipment. Coordinate purchases to ensure uniform interface with every item requiring electrical power.

3.8 CUTTING AND PATCHING

A. The Electrical Contractor shall be responsible for all cutting and patching of holes in building construction which are required for the passage of electrical work. Cutting and patching shall conform to the requirements of Division 1 and, if applicable, Division 2 of these specifications.

B. Cutting of structural framing, walls, floors, decks and other members intended to withstand stress is not permitted.

3.9 PAINTING, FINISHING

A. Painting of electrical work exposed in occupied spaces, except mechanical and electrical machine rooms and maintenance/service spaces; and work exposed on the exterior of the facility is specified and performed under other divisions of these specifications.

B. Factory finishes, shop priming, and special protective coatings are specified in the individual equipment specification sections.

C. Where factory finishes are provided on equipment and no additional field painting is specified, all marred or damaged surfaces shall be touched up or refinished so as to leave a smooth, uniform finish at the time of final inspection.

3.10 EXCAVATION AND BACKFILLING

A. Contractor shall perform all excavation and backfilling necessary to install the required electrical work. Coordinate the work with other excavating and backfilling work in the same area. Except as indicated otherwise, comply with the applicable sections in Division 31 of these specifications, excavation filling and backfilling (for structures) to 5' outside the building line, and exterior utilities sections for beyond 5' from the building line.

B. Landscape work, pavement, flooring and similar exposed finish work that is disturbed or damaged by excavation shall be repaired and restored to their original condition by the Contractor.

3.11 CONDUITS AND SUPPORT, GENERALLY

A. Conduits, except electrical conduits run in floor construction, shall be run parallel with or perpendicular to lines of the building unless otherwise noted on the drawings. Electrical conduits shall not be hung on hangers with any other service, unless specifically approved by the Engineer. Electrical conduits shall be hung above all other service pipes. Hangers on different service lines running close to and parallel with each other shall be in line with each other and parallel with, or perpendicular to, the lines of the building. Exact location of electric outlets, piping, ducts, and the like shall be coordinated to avoid interferences between lighting fixtures, piping, ducts, and similar items.

3.12 ACCESS PANELS

A. Furnish and install panels for access to junction boxes and similar items where no other means of access, such as a readily removable, sectional ceiling is shown or specified.

B. Panels shall not be less than 12-inches by 16-inches in size. Larger panels shall be furnished where required. Panels in tile or other similar patterned ceilings shall have dimensions corresponding to the tile or pattern module.

1. Refer to Section 08 31 13 – Access Doors and Panels for specific information on type and size of panels

3.13 INSTALLATION OF EQUIPMENT

A. Install and connect all appliances and equipment as specified and indicated for this project, in accordance with the manufacturers' instructions and recommendations. Furnish and install complete electric connections and devices as recommended by the manufacturer or required for proper operation.

3.14 ELECTRICAL DEMOLITION

A. Refer to Division 01 Sections for general demolition requirements and procedures.

B. Refer to the drawings for additional demolition requirements.

C. Disconnect, demolish, and remove electrical systems, equipment and components specified under Divisions 26, 27 & 28 and as indicated on the drawings.

1. For conductors serving devices shown to be removed: Disconnect the device and remove all conduit and conductors back to the panel or to the next device shown to remain or as required by actual circuiting.
2. Coordinate all phasing and related electrical system outages with the Owner and all other disciplines.
3. For mechanical equipment indicated shown to be removed on either the mechanical and/or the electrical plans: Disconnect the equipment and remove all conduit, conductors and associated electrical supply equipment. Remove conduit and conductors back to the panel or the next device shown to remain or as required by actual circuiting.

3.15 COORDINATION

A. Coordinate the electrical work with work of the different trades so that:

1. Interferences between mechanical, electrical, architectural, and structural work, including existing services, will be avoided.
2. Within the limits indicated on the drawings, the maximum practicable space for operation, repair, removal and testing of electrical and other equipment will be provided.
3. Pipe, conduits, ducts, and similar items, shall be kept as close as possible to ceiling, walls, and columns, to take up a minimum amount of space. Pipes, conduits, ducts, and

similar items shall be located so that they will not interfere with the intended use of other equipment.

B. Furnish and install, without additional expense to the Owner, all offsets, fittings and similar items necessary in order to accomplish the requirements of coordination.

C. Any work installed prior to approval of coordination drawings shall be at the Contractor's risk. Subsequent relocations required to avoid interference's shall be made without additional expense to the Owner.

3.16 SINGULAR NUMBER

A. Where any device or part of equipment is herein referred to in the singular number (such as "the switch"), such reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the drawings.

3.17 WARRANTY

A. Refer to the General Conditions section of this Specification for warranty requirements and information.

3.18 CLOSE OUT AND OPERATION INSTRUCTIONS

A. Sequence operations properly so that all work of this project will not be damaged or endangered. Operate each item of equipment and each system in a test run of appropriate duration to demonstrate sustained, satisfactory performance. Adjust and correct operations as required for proper performance.

B. Conduct a full-day walk-through instruction seminar for the Owner's personnel to be involved in the continued operation and maintenance of electrical equipment and systems. Explain the identification system, operational diagrams, emergency and alarm provisions, sequencing requirements, security, safety, efficiency and similar features of the systems.

C. At the time of substantial project completion, turn over the prime responsibility for operation of the electrical equipment and systems to the Owner's operating personnel. Until the time of final acceptance, provide full time operating personnel, who are completely familiar with the work, to consult with and continue training the Owner's personnel.

SUBSTITUTIONS

D. All proposals shall be based on providing and installing the materials or items of equipment which are hereinafter specified by name and/or manufacturer. Substitutions, for materials or items of equipment specified, will not be allowed, unless approved by Engineer prior to (10 days before) bid date.

E. Refer to Instructions to Bidders for complete requirements for substitutions.

3.19 AS-BUILT DRAWINGS

A. Contractor shall provide the Owner with as-built drawings for all electrical systems as described in these specifications and/or shown on the Drawings.

END OF SECTION 26 05 00

MOTOR TEST REPORT

DATE:_____
SHEET NO. _____ OF _____

PROJECT NAME: _____
PROJECT NUMBER:_____

DESIGNATION						
LOCATION						
HORSEPOWER						
NEMA STARTER SIZE						
MAXIMUM HEATER AMPS						
MEASURED CONDITIONS	PHASE			PHASE		
	A	**B**	**C**	**A**	**B**	**C**
ACTUAL MOTOR CURRENT						
NAMEPLATE MOTOR CURRENT						
NO LOAD VOLTAGE						
FULL LOAD VOLTAGE						

DESIGNATION						
LOCATION						
HORSEPOWER						
NEMA STARTER SIZE						
MAX HEATER AMPS						
MEASURED CONDITIONS	PHASE			PHASE		
	A	**B**	**C**	**A**	**B**	**C**
ACTUAL MOTOR CURRENT						
NAMEPLATE MOTOR CURRENT						
NO LOAD VOLTAGE						
FULL LOAD VOLTAGE						

ELECTRICAL TEST REPORT

DATE:_____
SHEET NO. _____ OF _____

PROJECT NAME: _____
PROJECT NUMBER:_____

SERVICE TRANSFORMER SIZE	
NO LOAD SERVICE VOLTAGE	
FULL LOAD SERVICE VOLTAGE	

DESIGNATION									
LOCATION									
MEASURED CONDITIONS	PHASE			PHASE			PHASE		
	A	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
NO LOAD FEEDER VOLTAGE									
OPERATING LOAD FEEDER VOLTAGE									
OPERATING LOAD FEEDER CURRENT									

DESIGNATION									
LOCATION									
MEASURED CONDITIONS	PHASE			PHASE			PHASE		
	A	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
NO LOAD FEEDER VOLTAGE									
OPERATING LOAD FEEDER VOLTAGE									
OPERATING LOAD FEEDER CURRENT									

SECTION 26 05 01- BASIC MATERIALS AND METHODS

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this Section.

1.2 DESCRIPTION OF WORK

A. The extent of Basic Materials and Methods is indicated by the drawings and specifications. Basic materials are defined but not limited to cable and conduit seals, outlet boxes, pull boxes, conduit fittings, safety switches, and fuses.

1.3 QUALITY ASSURANCE

A. Manufacturers: All materials shall be new, unused, and unweathered, and of the quality specified. Materials shall be standard products of manufacturer's regularly engaged in the production of such equipment and shall be the manufacturer's latest standard design.

B. Installer: All equipment and materials shall be installed in a neat and workmanlike manner, shall be complete in both effectiveness and appearance, whether finally concealed or exposed and shall be executed by experienced mechanics.

1.4 REFERENCES

A. The electrical work shall conform to all applicable sections of standards, codes and specifications promulgated by organizations listed below.

1. Occupational Safety and Health Standard, National Consensus Standards and Established Federal Standards
2. National Electrical Code (NEC)
3. National Electric Manufacturer's Association (NEMA)
4. American Society for Testing of Materials (ASTM)
5. Underwriters Laboratories, Inc. Standards (UL)
6. Factory Mutual Engineering Corporation or other Recognized National Laboratories

1.5 SUBMITTALS

A. Shop drawings: Prepare a set of shop drawings showing manufacturers product data for all component parts specified in this Section.

2. PRODUCTS

2.1 Equipment and Materials Furnished by Others: Certain materials and equipment for this project will be furnished under other divisions. These materials and equipment, which are shown or noted on the plans, will be installed and/or connected under this Division. It shall be incumbent upon this Contractor to become familiar with all of the materials and equipment that will be furnished under other Divisions, but which will be installed and/or connected under this Division.

2.2 Cable and Conduit Seals: Seals shall be provided around all conduits and cables which penetrate smoke walls, fire walls, and floors. Nelson Flameseal System shall be used to seal penetrations of electrical cables and conduits.

A. Materials used shall be flameseal putty, ceramic fiber insulation and where rigid support on large oversized openings is required, ceramic fiber board. Board shall be rigid and able to withstand temperatures in excess of 2000 degrees F.

B. Accessory hardware shall be provided as required on oversized openings.

C. Follow manufacturers instructions in selecting the type of seals and accessories. Also follow the manufacturers instructions on installation of the cable and conduit seals. Equal quality equipment by OZ Gedney and 3M shall be acceptable.

2.3 **Animal Area Sealants: All penetrations into animal area and containment area environments, including all conduits, cables, boxes, electrical devices, etc. shall be adequately sealed to maintain the environment. ASTM C920 compliant sealing and caulking compound shall be used to seal around all raceway, cable and box penetrations through Animal Area walls, ceilings and floors. Provide 100% silicone sealant between all surface mounted electrical devices and finished walls and ceilings within the Animal Area. Provide 100% silicone sealant between flush mounted electrical device faceplates and finished walls and ceilings within the Animal Area. For recessed lighting, provide non-halogenated latex-based elastomeric sealant along the perimeter of the lighting fixture housings where the housing of the fixture penetrates the animal area ceiling. For surface mounted lighting, provide non-halogenated latex-based elastomeric sealant along perimeter of fixture where fixture housing meets the animal area finished ceiling. Reference electrical details for additional sealant and caulking information.**

2.4 Outlet Boxes, Pull Boxes and Conduit Fittings: Furnish and install outlet boxes, pull boxes, and conduit fittings as described below. Catalog numbers shown are Appleton Electric Company; Steel City, O.Z. Gedney, and Raco, are equally acceptable.

A. OUTLET BOXES

1.	Lighting Boxes (concealed)	No. 40-3/4
2.	Lighting Boxes (concrete)	OCR Series

3.	Lighting Boxes (exposed)	4S-3/4 or 40-3/4
4.	Flush Switches, Receptacles and Flush Junction Boxes	No. 4S-3/4 with separate extension plaster ring; M*-250 in masonry construction (* refers to number of devices in the box)
5.	Weatherproof type Switch, Receptacle and Telecommunications Boxes (exposed) and **all devices installed within the Animal Area.**	FD Series w/FD cover and neoprene gasket.
6.	Switch, Receptacle and Telecommunications Boxes (exposed)	4S-3/4 with 8360 or 8370 series raised surface cover.

7. Telecommunications Boxes

   a. At minimum, the typical communications backbox shall be 4-11/16-inch square by 2-1/8- inch deep with 1-1/4-inch knockouts and a 4-11/16-inch square mud ring for one (1) device (single-gang) unless noted otherwise.

   b. For flush mounted boxes, Manufacturer shall be:

      1) RACO/Hubbell Electrical Products – 4-11/16-inch Square Box, 2-1/8-inch Deep, 1-1/4-inch Side Knockouts. (P/N RACO259) with 4-11/16-inch square mud ring for one (1) device (verify appropriate Mud-Ring depth).
      2) Randl Industries, Inc. – 5-square Telecommunications Outlet Box (P/N T55017) with appropriate single gang mud ring.
      3) Or approved equivalent.

   c. For outlets in CMU wall, submit appropriate backbox for application.
   d. For outlets above ceiling for applications such as Wireless Access Points

      1) RACO/Hubbell Single-gang Galvanized Steel Box (P/N 2DDB6)
      2) Or approved equivalent.

B. Extension and plaster rings shall be installed as required by the NEC.

C. Outlet boxes shall comply with the National Electrical Code in regard to the allowable fill.

2.5 PULL BOXES

A. Pull boxes shall be fabricated of code gauge galvanized sheet metal and shall be sized in accordance with the National Electrical Code requirements or as shown on the drawings. Provide removable cover on the largest access side of the box. In-line conduit pull boxes may

be O.Z., Type PBW, or equal. Provide pull boxes at all code required locations, and as needed to aid in cable pulling.

2.6 SAFETY SWITCHES

A. Furnish and install heavy duty type safety switches, having the electrical characteristics, ratings and modifications shown on the drawings. All switches shall have:

B. NEMA 1 general purpose enclosures unless otherwise noted for all interior applications;

C. NEMA 3R rainproof enclosures unless otherwise noted for all exterior applications and in all mechanical rooms;

D. NEMA 4/4X stainless steel enclosures unless otherwise noted in all animal areas.

E. Fully rated neutral assemblies;

F. Equipment grounding kits;

G. Metal nameplates, front cover mounted that contain a permanent record of switch type, catalog number and H.P. ratings with both standard and time delay fuses;

H. Handle that is padlockable in "OFF" position;

I. Non-teasible, positive quick-make, quick-break mechanism;

J. UL approval and shall bear the UL label;

K. All fusible switches shall have Class R Fuse rejection clips.

L. Safety switches, as manufactured by the following, will be equally acceptable, but all safety switches furnished by this Contractor shall be the product of one manufacturer:

1. Square D Company
2. General Electric
3. Cutler Hammer
4. Siemens

2.7 FUSES

A. Fuses shall be furnished and installed in each fused switch, and shall be rated as shown on the drawings.

B. Provide fuses according to the following and in accordance with recommendations of manufacturers whose equipment is being protected:

1. Provide UL Class L current limiting time-delay fuses rated 600-volts, 60 Hz, 601 to 6000 amps, with 200,000A RMS symmetrical interrupting current rating for protecting transformers, motors and circuit breakers. (Similar to Buss Low-Peak fuses.)
2. Provide UL Class L current limiting fast-acting fuses rated 600-volts, 60 Hz, 601 to 6000 amps, with 200,000A RMS symmetrical interrupting current rating for protecting service entrances and main feeder circuit breakers. (Similar to Buss Limitron fuses.)
3. Provide UL Class RK1 current limiting, dual-element, time-delay fuses rated 600-volts, 60 Hz, 1/10 to 600 amps, with 200,000A RMS symmetrical interrupting current rating for protecting motors and circuit breakers. (Similar to Buss Low-Peak fuses.)
4. Provide UL Class RK1 current-limiting fuses rated 250-volts, 60 Hz, 1/10 to 600 amps, with 200,000A RMS symmetrical interrupting current for protecting motors and circuit breakers. (Similar to Buss Low-Peak fuses.)
5. Provide UL Class J current-limiting fuses rated 600-volts, 60 Hz, 1 to 600 amps, with 200,000A RMS symmetrical interrupting current rating for protecting circuits with no heavy inrush current where reduced dimension devices are required.
6. Provide UL Class H fuses rated 600-volts, 60 Hz, 1/10 to 600 amps, with 10,000A RMS symmetrical interrupting current rating for protecting general purpose light duty feeders.
7. Provide UL Class T fuses rated 600-volts, 60 Hz, 1 to 1,200 amps, with 200,000A RMS symmetrical interrupting current rating for protection of non-motor loads where reduced dimension devices are required.

C. Three spare fuses shall be furnished for each size and type used. Each fused switch shall be provided with a mastic backed label clearly identifying the type and size of fuse required.

3. EXECUTION

3.1 PRODUCT INSTALLATION, GENERAL

A. Except where more stringent requirements are indicated, comply with product manufacturer's installation instructions and recommendations, including handling, anchorage, assembly, connections, cleaning and testing.

3.2 MOUNTING HEIGHTS

A. Mounting heights to the center of the box above finished floor for the items listed below shall be as follows, unless otherwise shown. All other device mounting heights shall be as shown on the drawings. All devices shall be mounted in accordance with ADA (Americans with Disabilities Act) requirements.

B. Flush tumbler switches and lighting controls 46"

C. Switches in concrete block 46"

D.	Switches over wainscot	6" above 48" wainscot
E.	Convenience outlets	18" mounted vertically with ground prong slot at bottom
F.	Safety switches	54"
G.	Motor controllers	54"
H.	Panelboards to top	72"
I.	Telecommunications outlets	18"
J.	Telecommunications outlets (pay and wall type)	54" for non-ADA type 44" for ADA type
K.	Clock outlets 8' ceiling 9' ceiling	84" 96"
L.	Receptacles above counters	8" above counters mounted vertically
M.	Convenience outlets in mechanical, electrical, telecommunications, janitor and elevator machine rooms	48”
N.	Exterior W.P. convenience outlets	24" above grade mounted
O.	Fire alarm pull station	46"
P.	Fire alarm horn, speaker, bell chime And/or strobe	84"
Q.	Intercom System Pushbutton Stations	46"
R.	Card Readers	46”

S. Contractor shall check all equipment layouts and verify exact mounting heights.

3.3 CUTTING AND PATCHING FLOORS, WALLS OR CEILINGS

A. Cutting, patching, repairing, and finishing of carpentry work, metal work, or concrete work, etc., which may be required for this work shall be done by craftsmen skilled in their respective trades. When cutting is required, it shall be done in such a manner as not to weaken walls, partitions, or floors. Holes required to be cut in floors must be drilled without breaking out around the holes. Cutting, patching, and painting shall conform to the requirements of the General Conditions section of this Specification.

B. Cutting of structural framing, walls, floors, decks, or other members intended to withstand stress is not permitted.

C. Sleeves through floors or walls shall be black iron pipe and shall be flush with finished faces of floors, walls or ceilings. Sleeves shall be sized to accommodate raceways indicated.

D. Use care in piercing water proofing. After the part piercing the waterproofing has been set in place, seal openings, and make absolutely watertight.

3.4 SLEEVES

A. Sleeves shall be used to accommodate conduit or tubing where conduit or tubing pass through newly poured concrete walls or slabs.

B. All sleeves through floors and walls shall be black iron pipe, flush with walls or finished floors; and of sizes to accommodate the raceways shown. Sleeves through outside walls above grade shall be caulked with approved caulking compound. Sleeves shall not be required through on grade slabs.

C. For raceways which enter buildings below grade, install manufactured floor and thruwall seals, similar to Type "FSK" or "WSK" as manufactured by O.Z. Electric Manufacturing Co.

D. For raceways that penetrate into the animal area, provide gas-tight and water-tight penetrations to maintain the integrity of the environment.

3.5 INSTALLATION METHODS

A. Conductors shall be installed in concealed raceways except as shown otherwise on the drawings or specified to be otherwise in these specifications. Exposed conduits and wires shall be installed parallel or perpendicular to building surfaces. Conduits and wires in the space above ceilings shall be supported adequately and shall not be laid on the top of ceiling systems. Conduits and wires installed above ceilings shall be considered exposed.

B. Electrical conduits shall not be hung on hangers with any other service foreign to the electrical systems, nor shall they be attached to other foreign services.

C. The lighting and power branch circuit conductors shall be installed in separate raceway systems unless specifically shown or noted otherwise.

D. Equipment Bases. Provide concrete equipment bases for all floor mounted equipment furnished under this contract. Concrete bases shall be 3-1/2"-inches high unless noted otherwise and shall extend 3-inches beyond all sides of the unit. Trowel all edges at a 45 degree angle. This work shall be done in accordance with Division 3 of the specifications by the Division 26 Contractor. Bases shall be provided for switchboards, motor control centers, transformers and all other floor mounted equipment.

E. Outlet Box Locations. Outlet boxes shall be located so they are not placed back-to-back in the same wall, and in metal stud walls, are separated by at least one stud space in order to limit sound transmission from room to room. Outlet boxes installed on opposite sides of fire rated walls shall be spaced at least 24" apart.

3.6 WIRING - NUMBER OF WIRES REQUIRED

A. The number of wires for lighting and receptacle branch circuits is shown on the drawings. The number of wires in any circuit is determined in accordance with the National Electrical Code, and wiring is provided to perform all functions of the devices being installed. Additionally, wires shall be provided as required by the contract documents, i.e. equipment grounds, etc. Provide the number of wires required for a complete and workable system.

3.7 PROTECTION FROM WEATHER

A. Raceway stub ups shall be capped or otherwise protected from moisture and debris until such time that the conductors are pulled. Conductors shall not be installed in raceways until the building is protected from the weather, all concrete and plastering is completed, and raceways in which moisture has collected have been swabbed or blown out.

3.8 ELECTRICAL ROOM COORDINATION

A. Where a number of electrical panels and/or related electrical items are shown, the Electrical Contractor shall coordinate the physical sizes with his equipment suppliers to ensure that there is adequate space for the items shown to be installed in those areas and that all Code required clearances are maintained.

B. The Contractor shall rearrange the equipment layout to achieve full use of the available space prior to installing conduit stub ups. Where a conflict or rearrangement exists, the Contractor shall submit a proposed revised layout of the area to the Engineer.

3.9 NAMEPLATES

A. Nameplates shall be provided for all items such as panelboards, cabinets, motor controllers (starters), safety switches, separately enclosed circuit breakers, individual breakers and controllers in switchboards and motor control centers, control devices and other significant equipment

B. Nameplates shall be 1"x 2-1/2" laminated phenolic resin (white background, black lettering) with engraved lettering, a minimum of 1/4-inch for grouped equipment/loads and minimum 1/8" high for individual equipment/loads. Manufacturers factory installed nameplates shall be acceptable provided all information is furnished.

C. Nameplates shall identify the equipment item that the device is serving and also from where the device is being fed from. Nameplates shall also identify the system voltage of the item of equipment.

D. Nameplates shall also be provided listing calculated SCCR at the main service distribution equipment and elevator controllers in accordance with NEC requirements.

E. Branch panelboards nameplates shall include name of panel in which it is served from.

F. All concealed junction boxes serving fire alarm devices shall be colored red and labeled "Fire Alarm" with a nameplate as described above.

3.10 RACEWAY SUPPORTS

A. Raceways shall be securely supported and fastened in place with pipe straps, wall brackets, caddy clips, hangers or trapeze hangers at intervals specified in Section 26 05 33 "RACEWAYS" or:

1. As shown on the drawings.

2. As may be required by special adverse field conditions.

B. Spring tension clamps on building steel work may be used only by special permission.

C. Fastenings shall be by wood screws or screw-type nails to wood; by toggle bolts on hollow masonry units; by expansion bolts on concrete or brick; by machine screws or welded threaded studs on steel work. Nail-type nylon anchors or threaded studs driven in by a powder charge and provided with lock washers and nuts may be used in lieu of expansion bolts or machine wood screws. Threaded C-clamps shall not be used. Raceways or pipe straps shall not be welded to steel structures. Holes cut in reinforced concrete beams or in concrete joists shall avoid cutting the main reinforcing bars. Holes not used shall be filled. In partitions of light steel construction, sheet-metal screws may be used, and bar hangers may be attached with saddle ties of not less than No. 16 AWG double strand zinc-coated steel wire. No raceway shall be attached to the suspended ceiling construction. Conduits shall be fastened to all sheet-metal boxes and cabinets with two locknuts and insulating bushings.

3.11 BOX SUPPORTS

A. Boxes and supports shall be fastened to wood with wood screws or screw-type nails of equal holding strength, with bolts and expansion shields on concrete or brick, with toggle bolts on

hollow masonry units, and with machine screws or welded studs on steel work. Plastic expansion shields shall not be used. Threaded studs driven in by powder charge and provided with lockwashers and nuts may be used in lieu of wood screws, expansion shields, or machine screws. In open overhead spaces, cast metal boxes threaded to raceways need not be separately supported except where used for fixture support; cast metal boxes having threadless connectors and sheet metal boxes shall be supported directly from the building structure or by bar hangers. Raceways shall be supported with an approved type fastener not more than 24-inches from the box. Penetration into reinforced concrete beams and into reinforced-concrete joists shall avoid cutting any main reinforcing steel.

3.12 LIGHTING FIXTURE SUPPORTS

A. Lighting fixtures shall be supported as follows and in accordance with all applicable Codes and Regulations:

1. By fixture studs or other devices securely attached to outlet box, or;
2. By special hangers designed and intended for use as lighting fixture supports, or;
3. By a special clip or device attached to the ceiling system grid designed to secure the lighting fixture in place or;
4. By other methods and devices designed and intended for use as lighting fixture support, or;
5. As shown on the drawings.
6. All lighting fixtures installed in grid type suspended ceiling systems, shall be positively attached to the ceiling system with clips that are UL listed for the application. In addition, a minimum of four (4) ceiling support system rods or wires shall be provided for each light fixture and shall be installed not more than six (6) inches from fixture corners. Provide two (2) No. 9 gage hangers from each fixture housing to the building structure above (wires may be installed slack). Light fixtures that weigh more than 56 pounds shall be supported directly from the structure above by UL listed and approved hangers. Light fixtures that are smaller than the ceiling grid shall be installed at locations indicated on the reflected ceiling plans, or shall be installed in the center of the ceiling panel and shall be supported independently by at least two metal channels that span and are secured to the ceiling system.
7. Suspended lighting fixtures shall be supported directly from the building structure without using suspended ceilings as support systems. Support systems shall be UL listed and approved for the specific installation. Where pendants or rods exceed 48 inches in length, brace support systems to limit swinging.

B. The lighting fixture support system detail shall be submitted with and be a part of the lighting fixture shop drawing submittal.

C. Lighting fixtures shall <u>not</u> be supported from the leg of pre-cast pre-stressed concrete.

END OF SECTION 26 05 01

SECTION 26 05 19 - CONDUCTORS

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work in this Section.

B. This Section is a Division 26 "Basic Materials and Methods" section, and is part of each Division 26 section making reference to conductors.

1.2 Description of Work: Extent of electrical wire and electrical cable work is indicated by drawings and schedules. Types of wire, cable and connectors in this Section include the following:

A. Conductors

B. Power-limited circuit cable

C. Service entrance cable

1.3 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in the manufacture of electric wire and cable products of types and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer: Qualified with at least 3 years of successful installation experience on projects with electrical wiring work similar to that required for this project.

1.4 REFERENCES

A. NEC Compliance: Comply with NEC as applicable to construction and installation of electrical wire, cable and connectors.

B. UL Compliance: Comply with UL standards pertaining to wire cable and connectors.

C. UL Labels: Provide electrical wires, cables and connectors which have been UL-listed and labeled.

D. NEMA/ICEA Compliance: Comply with applicable portions of NEMA/Insulated Cable Engineers Association Standards pertaining to materials, construction and testing of wire and cable.

E. ANSI/ASTM: Comply with applicable portions of ANSI/ASTM standards pertaining to construction of wire and cable.

F. IEEE Compliance: Comply with applicable portions of IEEE standards pertaining to wire and cable.

G. NECA Compliance: Comply with NECA's "Standard of Installation."

1.5 SUBMITTALS

A. Submit manufacturer's data on electric wire and cable.

2. PRODUCTS

2.1 Manufacturers: Subject to compliance with requirements, provide products of one of the following (for each type of wire, cable and connector):

A. WIRE AND CABLE:

1. Advance Wire and Cable, Inc.
2. Cerro Wire and Cable, Co.
3. Electrical Conductors, Inc.
4. General Cable Corp.
5. Hitemp Wires, Inc.
6. Rome Cable Corp.
7. Southwire Company
8. The Okonite Company
9. Encore Wire

B. CONNECTORS:

1. Amp, Inc.
2. Burndy Corp.
3. Eagle Electric Mfg. Co., Inc.
4. Gould, Inc.
5. Ideal Industries, Inc.
6. Josylyn Mfg. and Supply Co.
7. O-Z/Gedney Co.
8. Pyle National Co.
9. Thomas and Betts Co.

2.2 WIRE, CABLE, AND CONNECTORS

A. General: Except as otherwise indicated, provide wire, cable and connectors of manufacturer's standard materials, as indicated by published product information; designed and constructed as recommended by manufacturer, and as required for the installation.

B. WIRE:

1. All conductors shall be 600-volt and shall be copper, soft drawn, annealed, having a conductivity of not less than 98% pure copper with dual rated type THHN/THWN insulation unless otherwise specified or indicated on the drawings.
2. No wire shall be smaller than No. 12 AWG, except wiring for signal and pilot control circuits, and pre-manufactured fixture whips for light fixtures.
3. All wire No. 10 AWG and smaller shall be solid unless otherwise indicated within these specifications. All wire No. 8 AWG and larger shall be stranded.
4. All wiring installed in light poles or other areas subject to vibration shall be stranded.
5. Wire sizes shown are minimum based on code requirements, voltage drop and/or other considerations. Larger sizes may be installed at the Contractor's option to utilize stock size, provided conduit sizes are increased where necessary to conform to the National Electrical Code. Sizes of wires and cables indicated or specified are American Wire Gage (Brown and Sharpe).
6. All feeder and branch circuit wiring shall be color-coded as follows:

PHASE	120/208 VOLT	277/480 VOLT
A	Black	Brown
B	Red	Orange
C	Blue	Yellow
Neutral	*White	*White
Ground	Green	Green

*Except as provided in paragraph 200.6 of the NEC.

C. ALUMINUM WIRE:

1. Aluminum conductors shall not be substituted for copper conductors.

D. CONNECTIONS

1. Wire connections shall be as follows unless otherwise indicated on the drawings.

   a. Use preinsulated connectors 3M Company "Scotchlok," or Ideal Industries, Inc. "super nut," for splices and taps in conductors No. 10 AWG and smaller. All other twist-on connectors must be reviewed by the Architect prior to installation. Use this type of connector for factory-made splices in fixtures or equipment.
   b. Pressure indent type connectors must be submitted to the Architect for review.
   c. Tape all splices and joints with vinyl plastic tape manufactured by Minnesota Mining and Manufacturing Company. Use sufficient tape to secure insulation strength equal to that of the conductors joined.

d. Keep splices in underground junction boxes to an absolute minimum. Where splices are necessary, use resin pressure splices and resin splicing kits manufactured by the 3M Company, St. Paul, Minnesota, to totally encapsulate the splice. Arrange the splicing kit to minimize the effects of moisture.

e. Connect wire No. 6 AWG and larger to panels and apparatus by means of approved lugs or connectors.

f. Connect wire No. 10 AWG and larger to panels, motors and electrical apparatus using OZ (or equivalent) type XL set screw type lugs. Lugs shall accommodate full wire capacity for stranded conductors. All connections and connectors shall be solderless.

g. Connectors of the porcelain cup type with or without metal inserts shall not be used, including all splices in fixtures which are made in advance by the fixture manufacturer. Splices in wire No. 8 AWG and larger shall be made with approved solderless lugs. If any type of pressure indent type connector is proposed for use on any size conductor, it shall be specifically submitted for approval prior to use.

3. EXECUTION

3.1 INSTALLATION

A. General: Install electric cables, wires and connectors as indicated in compliance with manufacturer's written instructions, applicable requirements of the NEC and NECA's "Standard of Installation", and in accordance with recognized industry practices.

B. Coordinate cable and wire installation work with electrical raceway and equipment installation work, as necessary for proper interface.

C. Conductors shall be continuous from outlet to outlet and no splices shall be made except within outlet or junction boxes. Junction boxes may be utilized wherever required.

D. Splicing: No splicing or joints will be permitted in either feeder or branch circuits except at outlet or accessible junction boxes.

E. Wire shall not be installed in raceways until the concrete work and plastering is completed and all conduits in which moisture has collected have been swabbed out. Insulation resistance to ground shall not be less than that approved by NEC. Eliminate splices wherever possible.

F. Use pulling compound or lubricant where necessary. Compound must not deteriorate conductor insulation.

G. Prior to energization, check cable and wire for continuity of circuitry, and for short circuits. Correct malfunctions when detected.

H. Bury a continuous, pre-printed, bright colored plastic ribbon cable marker with each underground cable, regardless of whether conductors are in conduit. Locate each directly over cables 12" below finished grade.

I. Conductor Installation: Install all conductors in a single raceway at one time, insuring that conductors do not cross one another while being pulled into raceway. Leave sufficient cable at all fittings or boxes and prevent conductor kinks. Keep all conductors within the allowable tension and exceeding the minimum bending radius.

J. Conductor Support: Provide conductor supports as required by the code and recommended by the cable manufacturer. Where required, provide cable supports in vertical conduits similar to OZ Type C.M.T., and provide the lower end of conduit with OZ Type KVF ventilators.

K. Conductor Termination: Provide all power and control conductors, that terminate on equipment or terminal strips, with solderless lugs or fork and flanged tongue terminals. Provide T and B "sta-kon" tongue terminal. This type conductor termination is not required when the equipment is provided with solderless connectors.

L. Provide dedicated neutral conductors for all branch circuits. Neutral conductors shall not be shared between circuits.

3.2 CONDUCTOR ARCPROOFING

A. Cover two or more power feeder cables occurring in the same switchboard section, junction box or pull box (including pull boxes over switchboards) with arcproof and flameproof tape.

B. Provide 3M Company "Scotch" No. 77 tape or Plymouth Rubber Co. Slipknot No. 30 tape, to provide an installation capable of withstanding a 200-amp arc for not less than 30 seconds.

C. Apply tape in a single layer, one-half lapped, or as recommended by the manufacturer to conform to the above requirements. Apply with the coated side next to the cable and hold in place with a random wrap of 1/2 inch wide, pressure-sensitive, glass cloth electrical tape, 3M Company "Scotch" No. 69. Tape to be color coded as specified previously.

END OF SECTION 26 05 19

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SECTION 26 05 26 - GROUNDING SYSTEM

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this Section.

B. Division 26 "Basic Materials and Methods" sections apply to work of this Section.

1.2 DESCRIPTION OF WORK

A. Extent of grounding work is indicated by the drawings and is specified herein.

B. Applications of grounding work in this Section include the following:

1. Underground Metal Piping
2. Underground Metal Water Piping
3. Metal Building Frames
4. Ground Rods
5. Separately Derived Systems
6. Service Equipment
7. Enclosures
8. Equipment

C. Requirements of this Section apply to electrical grounding work specified elsewhere in these specifications.

1.3 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in manufacture of electrical connectors, terminals and fittings, of types and ratings required, and ancillary grounding materials, including stranded cable, copper braid and bus, ground rods and plate electrodes, whose products have been of satisfactory use in similar service for not less than three years.

B. Installer: Qualified with at least three (3) years experience on projects with electrical grounding work similar to that required for this project.

1.4 REFERENCES

A. NEC Compliance: Comply with NEC requirements as applicable to materials and installation of electrical grounding systems, associated equipment and wiring. Provide grounding products which are UL listed and labeled.

B. UL Compliance: Comply with applicable requirements of UL Standard Nos. 467 and 869 pertaining to electrical grounding and bonding.

C. IEEE Compliance: Comply with applicable requirements of IEEE Standard 142 and 241 pertaining to electrical grounding.

D. Utility: Grounding shall be done so as to comply with all applicable grounding requirements and rules of the serving utility.

E. NECA Compliance: Comply with NECA's "Standard of Installation."

1.5 SUBMITTALS

A. Product Data: Submit manufacturers data on grounding systems and accessories.

B. Shop Drawings: Submit layout drawings of grounding systems and accessories including, but not limited to, ground wiring, copper braid and bus, and ground rods.

2. PRODUCTS

2.1 Acceptable Manufacturers: Subject to compliance with the requirements, provide grounding products of one of the following:

A. B-Line Systems

B. Burndy Corporation

C. Crouse Hinds

D. Electrical Components Div.; Gould Inc.

E. General Electric Supply Co.

F. Ideal Industries, Inc.

G. Thomas and Betts Corp.

H. Western Electric Co.

2.2 Grounding Systems: Except as otherwise indicated, provide electrical grounding systems indicated; with assembly of materials, including but not limited to cables/wires, connectors, terminals, ground rods/electrodes, bonding jumper braid, and additional accessories needed for a complete installation. Where more than one type unit meets indicated requirements, selection

is installer's option. Where materials or components are not indicated, provide products complying with NEC, UL, IEEE and established industry standards for applications indicated.

2.3 Conductors: Unless otherwise indicated, provide electrical grounding conductors for grounding connections matching power supply wiring materials and sized according to NEC requirements.

2.4 Bonding Jumper Braid: Provide copper braid tape, constructed of 30 gage bare copper wires and properly sized for indicated applications.

2.5 Flexible Jumper Strap: Provide flexible flat conductor, 480 strands of 30 gage bare copper wire; 3/4" wide, 9-1/2" long; 48,250 cmil. Protect braid with copper bolt hole ends with hole sized for 3/8" dia. bolts.

2.6 Bonding Plates, Connectors, Terminals and Clamps: Provide electrical bonding plates, connectors, terminals, lugs and clamps as recommended by bonding plate, connector, terminal and clamp manufacturers for indicated applications.

2.7 Ground Rods: Provide steel ground rods with copper welded exterior, 3/4" dia. x 10'.

2.8 Electrical Grounding Connection Accessories: Provide electrical insulating tape, heat-shrinkable insulating tubing, welding materials, and bonding straps as recommended by accessories manufacturers for types of service indicated.

3. EXECUTION

3.1 GENERAL

A. Inspection: Installer must examine areas and conditions under which electrical grounding connections are to be made and notify the Architect/Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the installer.

B. General: Install electrical ground systems where shown, in accordance with applicable portions of the NEC, with NECA's "Standard of Installation", and in accordance with recognized industry practices to ensure that products comply with requirements and serve intended functions.

C. Coordinate with other electrical work as necessary to interface installation of electrical grounding systems with other work.

D. Grounding and bonding of electrical installations and specific requirements for systems, circuits and equipment required to be grounded shall be accomplished for temporary and permanent construction.

E. Provide a separate green equipment ground conductor in all electrical raceways to effectively ground all fixtures, panels, receptacles, controls, motors, disconnect switches, exterior lighting

standards and noncurrent carrying metal enclosures. The ground wires shall be connected to the building system ground. NEC Table 250.122 shall be used to size the ground conductor if the size is not shown on the drawings.

F. To satisfy the "effective grounding" requirements of the NEC the path to ground from circuits, equipment, and conductor enclosures shall be permanent and continuous and shall have ample carrying capacity to conduct safely any currents liable to be imposed on it, and shall have impedance sufficiently low to limit the potential above ground and to facilitate the operation of the overcurrent devices in the circuit.

G. Building columns, roof steel, and footer steel reinforcing shall be electrically continuous.

H. Ground the service in accordance with provisions of the National Electrical Code and the contract drawings.

I. Clean the contact surfaces of all ground connections.

J. Where separately derived systems occur, ground the system to a grounding electrode acceptable to the code.

K. Provide equipotential plane and required bonding for all animal holding areas in the building. Equipotential plan shall meet all requirements as dictated in NEC Article 547.

L. An onsite meeting shall be held including electrical contractor, general contractor, concrete contractor, and design team once all equipotential plane bonding to structural rebar has been installed, but before concrete is poured. General contractor shall be responsible for coordinating and organizing such meeting.

M. Install metallic raceways mechanically and electrically secure at all joints and at all boxes, cabinets, fittings and equipment. At the point of electrical service entrance, bond all metallic raceways together, with a ground conductor, and connect to the system ground bus. Bond all boxes as specified for equipment.

N. Receptacles: Permanently connect the ground terminal on each receptacle to the green ground conductor.

O. Motors: Connect the ground conductor to the conduit with an approved grounding bushing, and to the metal frame with a bolted, solderless lug.

P. New rebar as a part of the building addition shall be bonded to any new structural steel via (1) 3/0 copper grounding conductor that is cadwelded to rebar at one end and structural steel at the other end. The rebar utilized for the bonding connection shall be a minimum #4 size rebar and at least 20' in length.

Q. New structural steel frame shall be bonded to the existing structural steel frame via (1) 3/0 copper grounding conductor cadwelded at both connection points. Provide slack length in the conductor connecting the two building steel frames together as when bonding steel framing across a building expansion joint.

END OF SECTION 26 05 26

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SECTION 26 05 33 - RACEWAYS

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this Section.

B. This Section is a Division 26 "Basic Materials and Methods" section, and is part of each Division 26 section making reference to electrical raceways specified herein.

1.2 DESCRIPTION OF WORK

A. Extent of raceways is indicated by drawings and schedules.

B. Types of raceways in this Section include the following:

1. Electrical metallic tubing.
2. Flexible metal conduit.
3. Intermediate metal conduit.
4. Liquid-tight flexible metal conduit.
5. Rigid metal conduit.
6. Rigid nonmetallic conduit.
7. Surface metal raceways.

1.3 REFERENCES

A. NEMA Compliance: Comply with applicable requirements of NEMA standards pertaining to raceways.

B. UL Compliance and Labeling: Comply with provisions of UL safety standards pertaining to electrical raceway systems; and provide products and components which have been UL-listed and labeled. Each length of raceway shall bear the Underwriters Laboratories label.

C. NEC Compliance: Comply with NEC requirements which are applicable to the construction and installation of raceway systems.

D. NECA Compliance: Comply with NECA's "Standard of Installation".

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's data including specifications, installation instructions and general recommendations, for each type of raceway required.

2. PRODUCTS

2.1 STEEL CONDUIT

A. Steel Conduit: Rigid steel conduit, intermediate metal conduit and steel electrical metallic tubing shall be hot-dipped, galvanized or sheradized as manufactured by Youngstown Sheet and Tube Company, National Electric, General Electric, or equal.

B. Joints: Raintight non-insulated throat type compression fittings (connectors and couplings) shall be provided for electrical metallic tubing systems. All fittings shall be of the steel type with steel locknuts equal to Appleton 95 Series.

C. Expansion Joints: Provide expansion fittings, O.Z. Type AX with bonding jumper for rigid conduit and O.Z. Type TX with bonding jumper for electrical metallic tubing. Where embedded raceways cross building expansion joints, provide combination deflection/expansion fittings, O.Z. Type AXDX, or equal.

2.2 RIGID NON-METALLIC (PVC) CONDUIT

A. PVC (polyvinyl chloride) Conduit: Heavy wall rigid PVC conduit shall be composed of high impact PVC and shall conform to industry NEMA Standards and to Federal Specification WC-1094. Conduits shall be Carlon Schedule 40 type, Schedule 80 type, or approved equal.

2.3 FLEXIBLE METAL CONDUIT

A. Flexible metal conduit shall conform to UL1. It shall be formed from continuous length of spirally-wound, interlocked zinc-coated strip steel.

B. **Pre-wired armored cabling, types AC or MC are not allowed.**

2.4 LIQUID-TIGHT, FLEXIBLE METAL CONDUIT

A. Liquid-tight flexible metal conduit shall be constructed of a single strip, flexible, continuous, interlocked, and double-wrapped steel; galvanized inside and outside; and coated with an oil-resistant, liquid-tight thermoplastic jacket.

2.5 WIREWAYS

A. General: Provide electrical wireways of types, grades, sizes, weights (wall thicknesses), and number of channels for each type service indicated. Provide complete assembly of wireways including, but not necessarily limited to couplings, offsets, elbows, expansion joints, adapters,

hold down straps, end caps, and other components and accessories as needed for a complete system. Where types and grades are not indicated, provide proper selection as determined by the Installer to fulfill wiring requirements and comply with applicable provisions of NEC for electrical raceways.

B. Surface Metal Raceways: Provide surface metal raceways of sizes and channels indicated; in compliance with FS W-C-582. Construct of galvanized steel with snap-on covers, with 1/8" mounting screw knockouts in base approximately 8" o.c. Provide fittings indicated which match and mate with raceway. Finish with manufacturer's standard prime coating suitable for painting. Provide all necessary devices as shown on the drawings for a complete installation.

C. Manufacturers: Subject to compliance with requirements, provide surface metal raceways of one of the following:

1. B-Line Systems, Inc.
2. Midland-Ross Corporation
3. Power-Strut Division; Youngstown Sheet and Tube Company
4. Square D Company
5. Versa-Tech Corporation
6. Walker/Parkersburg Division; Textron, Inc.
7. Wiremold Company

3. EXECUTION

3.1 GENERAL

A. Install electric raceways where indicated; in accordance with manufacturer's written instructions, applicable requirements of the NEC and NECA's "Standard of Installation" and complying with recognized industry practices.

B. Raceways embedded in earth below floor slabs shall be rigid steel conduit, intermediate metal conduit or rigid schedule 80 PVC conduit and shall be a minimum of 12” below the concrete slab. Conduit shall be provided with Schedule 80 conduit elbows when the raceway system exits the concrete topping or earth. No conduit shall be embedded in concrete.

C. Electrical metallic tubing shall not be embedded in concrete, installed in earth, or installed exposed to weather.

D. Rigid heavy wall Schedule 80 PVC conduit shall be installed in earth and concrete only.

E. Raceways in outside walls (excluding building perimeter) or in refrigerated areas shall be rigid steel conduit, or intermediate metal conduit.

F. Provide rigid steel conduit or intermediate metal conduit for exposed raceways from floor to eight feet above the floor in mechanical rooms and in areas designated on the plans.

G. Rigid galvanized steel conduit or galvanized intermediate metal conduit shall be used where conduit is exposed to weather.

H. Rigid galvanized steel or intermediate metal conduit and cast boxes with external hubs shall be used to serve electrical devices located in all animal area environments.

I. Conduits in hazardous locations shall conform to the National Electrical Code. Rigid galvanized steel conduit or intermediate metal conduit shall be used in hazardous locations. PVC conduit shall not be used in hazardous areas.

J. Rigid metal, intermediate metal, electric metallic tubing or PVC conduit where allowed in other section 3.1 paragraphs shall be used for feeders and branch circuits.

K. Flexible metal conduit may be used to connect light fixtures in accordance with NEC requirements but must be limited to a maximum of 6'-0" in length. "Daisy chaining" from fixture to fixture is not permitted. Provide flexible metal conduit for connections to motors, transformers, generators, and other equipment subject to vibration. Length of flexible conduit shall be a minimum of one foot for conduit diameters up to 1-1/2". A minimum of 3" of flexible conduit shall be added for every 1/2" increase in conduit diameter. Flexible metal conduit installation shall be kept to a minimum in connecting other electrical equipment items. Sealtight, flexible conduit shall be used where the flexible conduit may be subject to moist or humid atmosphere, corrosive atmosphere, subject to water spray and subject to dripping oil, grease or water. **Flexible metal conduits shall not be permitted for any other applications, unless specifically approved by the Owner**

L. Conduits shall be 3/4" diameter, minimum. Raceway sizes shown on the drawing are based on type THHN/THWN conductors.

M. Type Material: Except as noted otherwise all conduit shall be steel.

3.2 INSTALLATION

A. All raceways shall be installed concealed except where shown or noted otherwise.

B. At the Owner's option, concealed raceways may be routed below the slab. At the Contractor's option, concealed raceways may be installed in furred spaces above ceilings or behind walls. Raceways shall not be embedded in concrete slab.

C. Continuity: Provide metallic raceways continuous from outlet to outlet, and from outlets to cabinets, junction or pull boxes. Enter and secure conduit to all boxes to provide electrical continuity from the point of service to outlets. Provide double locknut and bushing on terminals of metallic conduits.

D. A nylon or polypropylene pull string shall be installed in all empty conduits to facilitate future installation of cabling.

E. Provide accessible "seal-off" fittings for all raceways entering or leaving the **animal facility area**, hazardous areas, and as otherwise required by the National Electrical Code.

F. Where conduits penetrate the roof seal, they shall be installed in curbs provided for mechanical equipment. When this is not possible, suitable pitch pockets, lead flashing, or approved fittings shall be provided. Details for special conduit installations shall be as shown on the drawings.

G. Reinforced Concrete: No reinforcing steel shall be displaced to accommodate the installation of raceways and outlet boxes. Outlet boxes shall not be installed in beams or joists. In general, all embedded conduits shall be located in the physical center of the particular section of concrete. Unless otherwise indicated, raceways embedded in reinforced concrete shall conform to the following usual types of conditions. Particular attention is called to the fact that there are many extenuating conditions where the Contractor may be instructed in writing during the course of the project not to place embedded conduits in certain areas, generally due to the possibility of unsightly cracking or for structural reasons. This instruction shall not entitle the Contractor to extra compensation. Any condition not covered by the following usual conditions shall require special clarification.

	Location	Maximum Allowance
1.	Columns	Displacement of 4 percent of plan area of column.
2.	Floors and Walls	Displacement of 1/3 of thickness of concrete spaced not less than three diameters on center.
3.	Beams and Joists	Displacement of 1/3 of least dimension, spaced not less than three diameters on center.
4.	Sleeves thru Floors and Walls	2" maximum pipe size, not less than three diameters on center.

H. Plain Concrete: Raceways shall not be placed in plain concrete, such as cement toppings on structural floors without special instructions.

I. Furred Spaces: Raceways installed in furred spaces shall be installed in accordance with the requirements of the National Electrical Code. Do not anchor or strap conduits to the ceiling furring channels or attach to furred ceiling hanger wires. Raceways may be attached to the suspension system (wire hangers) of drop ceilings if installed in such a manner that the ceiling panels may be removed without interference with the raceway, and the wire hangers are sized to carry the additional raceway load.

J. Stub Ups: Extend conduit stubs at least one foot above slab or fill, before connection is made to electrical metallic tubing.

K. Exterior Conduits: Install raceways a minimum of 42” below finished grade unless noted otherwise on the drawings.

L. Provide marking of conduit and junction boxes to indicate which distribution system they are serving. The markings could be colored tape on conduit at or near junction boxes with different colored tapes indicating different distribution systems. Concealed junction boxes shall be legibly marked with a magic marker to indicate the panel and circuit number that junction box serves. All covers for wiring boxes used for fire alarm systems shall be colored red and labeled "fire alarm" using a phenolic equipment nameplate.

1. The distribution systems shall be color coded as follows:

   a. Fire Alarm - Red
   b. 120/208 Volt - Green
   c. 277/480 Volt - Orange
   d. Cable TV System - Black
   e. Telephone System - White

M. Steel Conduit (galvanized rigid steel, IMC or EMT):

1. Cutting: Cutting shall be done with hand or power hacksaws. All cut ends shall be reamed to remove burrs and sharp edges.
2. All threaded joints shall be made up wrench-tight and all compression joints shall be made up mechanically secure and snug so as to make continuous current-carrying electrical contact.
3. All metallic conduits buried or otherwise in contact with earth shall be painted using one heavy continuous coat of asphalt varnish after assembly of conduit and fittings.
4. Elbows for rigid metal conduit, 3 inches and larger, shall be either plastic coated or tape coated rigid metal conduit to prevent damage from pull ropes.
5. Rigid metal conduit shall be used for at least the first 5 feet of horizontal run out from the building to allow for building settling over time.
6. Expansion joints shall be installed in steel conduit systems in structures as follows expansion joints are specified elsewhere in the specification):

   a. Where conduit run crosses a building expansion joint.
   b. In any conduit run exceeding 100 feet in length.
   c. Where shown on the drawings.

N. Threads: Clean all threads of rigid or intermediate metal conduit. Coat all male threads of all steel conduit installed in concrete with red or white lead immediately before being coupled together.

O. Running Threads: Use "Erickson" type couplings in lieu of running threads.

P. PVC Conduit:

1. Joints: Conduits shall be joined by using couplings and solvent cement furnished or recommended by the raceway manufacturer. Finished joints shall be secure and watertight.

2. Cutting: Cutting shall be done with hacksaws and ends shall be reamed to remove burrs and sharp edges.
3. Expansion Joints: Expansion joints shall be installed:

    a. Where conduit run crosses a building expansion joint.
    b. As recommended by the manufacturer or as shown on the drawings.

4. Bends for PVC conduit sizes 2" and smaller may be made "hot" in the field. Inside dimension shall be thereby undistorted. For PVC sizes larger than 2", provide only factory bends.

END OF SECTION 26 05 33

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SECTION 26 05 73 – LOW VOLTAGE ELECTRICAL SYSTEMS STUDIES

1. GENERAL

1.1 DESCRIPTION OF WORK

A. The scope of this section is to provide requirements for low voltage (600 volts and below) studies and documentation. This includes short circuit analysis with equipment evaluation, overcurrent protective device coordination, and arc flash analysis.

B. **The Coordination Study and the Arc Flash Hazard Analysis shall be submitted along with and at the same time as the shop drawings for all pertinent electrical distribution equipment. Electrical distribution equipment shall not be released for purchase until study has been reviewed and approved by engineer.**

2. EXECUTION

2.1 SUBMITTALS

A. A coordination study shall be provided by the contractor for this project. The study shall include maximum short circuit calculations, a complete coordination analysis, and settings for all protective devices with adjustable set points. The protective device settings must address the need to minimize arc flash hazards while maintaining proper system coordination. The coordination study shall be based on the specific devices installed and include all **new equipment and all existing equipment required in order to complete the study for the new equipment** (including, but not be limited to) the following:

1. Service Entrance Equipment.

    a. All overcurrent protective devices installed in service entrance panels/switchboards.

2. Feeder Circuits.

    a. All three (3) phase feeder circuit overcurrent protective devices.

3. Branch Circuits.

    a. All three (3) phase branch circuit overcurrent protective devices. installed with a rating equal to or greater than 30 amps.
    b. All motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horse power.

4. Motor Control Centers

    a. All motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horse power.

5. Format

   a. The coordination study shall be reviewed and updated to reflect any changes within one week of the final electrical walk through for project.
   b. The low voltage coordination study shall include the stamp or seal and signature of the preparing engineer, and shall be reviewed by the Engineer of Record.
   c. A complete set of manufacturers' descriptive literature and detailed instructions for adjusting overcurrent protective devices shall be provided to the Owner's Representative within six (6) weeks after overcurrent protective device shop drawings have been approved.
   d. The low voltage coordination study shall be provided using the SKM Systems Analysis, Inc SKM Power Tools Electrical Engineering Software (PTW 32).
   e. Prior to project completion, the low voltage coordination study shall be provided to the Owner's Representative in both hard copy and in digital format. The hard copy shall include time current curves (for phase and ground fault settings) for each panel and the corresponding TCC report clearly showing each device set point. The digital copy shall include the complete coordination file including all device curves (use the SKM "Project - Backup" command).

B. A low voltage Arc Flash Hazard Analysis shall be provided by the contractor for this project. The analysis shall be based on the specific equipment installed, and shall be updated to include project "as built" documentation. The Arc Flash Hazard Analysis shall utilize owner's existing SKM study for the existing portion of the electrical distribution and shall be updated/expanded for all new equipment installed under this project's scope of work. Coordinate with owner. Where the arc flash incident energy greater than 8 cal/cm2, the overcurrent protective device coordination study shall be reviewed and recommendations shall be provided to reduce the hazard/risk level. The analysis shall be based on the specific devices installed and include all **new equipment and all existing equipment required in order to complete the study for the new equipment** (including, but not be limited to) the following:

   1. Service Entrance Equipment.

      a. All overcurrent protective devices installed in service entrance panels/switchboards.

   2. Feeder Circuits.

      a. All three (3) phase feeder circuit overcurrent protective devices.

   3. Branch Circuits.

      a. All three (3) phase branch circuit overcurrent protective devices installed with a rating equal to or greater than 30 amps.
      b. All motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horse power.

   4. Motor Control Centers.

a. All motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horse power.

5. The project shall include printed waterproof labels for equipment that lists the specific arc flash hazard/risk category at each location.

6. Format

a. The Arc Flash Hazard Analysis shall be reviewed and updated to reflect any changes and corrections to conductor length within one week of the final electrical walk through for the project.
b. The low voltage arc flash hazard analysis shall include the stamp or seal and signature of the preparing engineer, and shall be reviewed by the Engineer of Record.
c. Owner approved Arc Flash Hazard warning labels shall be furnished and installed prior to project completion.

1) The project include color, printed waterproof labels.
2) For incident energy values less than or equal to 40 cal/cm2, label shall indicate “WARNING” using black lettering on orange background.
3) For incident energy values greater than 40 cal/cm2, label shall indicate “DANGER” using white lettering with red background.
4) Labels installed outdoors shall be resistant to ultraviolet light.
5) At a minimum, each label shall list the following:

a) Location
b) Source protective device name providing the protection (fed from)
c) Nominal system voltage
d) Arc flash boundary
e) Specific arc incident energy available
f) Bolted Fault Current available
g) Label Date

d. The low voltage arc flash hazard analysis shall be provided using the SKM Systems Analysis, Inc SKM Power Tools Electrical Engineering Software (PTW 32). Do not use the “Use Equipment Specific Arc Flash Equation in Protective Device Library” method for arc flash calculation in the SKM Software.
e. Prior to project completion, the low voltage arc flash hazard analysis shall be provided to the Owner’s Representative in both hard copy and digital format. The hard copy shall clearly show each device set point. The digital format shall include the complete coordination file including all device curves (use the SKM “Project - Backup” command).

END OF SECTION 26 05 73

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SECTION 26 22 00 - DRY-TYPE TRANSFORMERS

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this Section.

1.2 DESCRIPTION OF WORK

A. Extent of transformer work is indicated by drawings and schedules.

B. Types of transformers specified in this Section include the following:

1. Energy Efficient Dry-type Transformers
2. Shielded, Isolation Type Transformers

C. Refer to other Division 26 sections for electrical wiring connections required in conjunction with transformers; not work of this Section.

1.3 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in the manufacture of power distribution transformers of types and ratings required, whose products have been in satisfactory use in similar service for not less than five (5) years.

B. Installer: Qualified with at least three (3) years successful installation experience on projects with electrical power/distribution transformer work similar to that required for this project.

1.4 REFERENCES

A. NEC Compliance: Comply with NEC as applicable to installation and construction of electrical power/distribution transformers.

B. NEMA Compliance: Comply with applicable portions of the NEMA Std. Pub. Nos. TR1 and TR27 pertaining to power/distribution transformers.

C. ANSI Compliance: Comply with applicable ANSI standards pertaining to power/distribution transformers.

D. ANSI/IEEE Compliance: Comply with applicable ANSI/IEEE standards pertaining to power/ distribution transformers..

E. ANSI/NEMA Compliance: Comply with NEMA Std. ST 20 "Dry-Type Transformers for General Applications".

F. ANSI/UL Compliance: Comply with applicable portions of ANSI/UL 506 "Safety Standard for Specialty Transformers".

G. UL Labels: Provide distribution transformers that have been UL listed and labeled.

H. IECC Compliance: Transformers shall be fully compliant with provisions of the International Energy Conservation Code, 2018 Edition.

1.5 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data including KVA rating, frequency, primary and secondary voltages, percent taps, impedance and certification of transformer performance efficiency at indicated loads, no load and full load losses in watts, hot spot and average temperature rise above 40 degrees C ambient, sound level in decibels, and standard published data.

B. Shop Drawings: Submit manufacturer's drawings indicating dimensions and weight loading for transformer installations.

2. PRODUCTS

2.1 Manufacturers: Subject to compliance with requirements, provide products of one of the following (for each type of transformer):

A. Cutler Hammer

B. General Electric Co.

C. Square D Co.

D. Siemens

2.2 EQUIPMENT

2.3 Furnish and install dry-type transformers as shown on the drawings.

A. Transformer coils shall be of the continuous **copper wound construction**.

B. All transformer cores shall be constructed with low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point to prevent core overheating. There shall be no metal-to-metal contact between the core and coil and the enclosure except for a flexible safety ground strap. Sound isolation systems requiring the complete removal of all fastening devices will not be acceptable.

C. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable UL and NEC standards.

D. The transformer enclosures shall be ventilated and be fabricated of heavy gauge, sheet steel construction. The entire enclosure shall be finished utilizing a continuous process consisting of degreasing, cleaning and phosphatizing, followed by electrostatic deposition of polymer polyester powder coating and baking cycle to provide uniform coating of all edges and surfaces. The coating shall be UL recognized for outdoor use. The coating color shall be ANSI 49.

E. Dry-type transformers shall have metallic enclosures designed to provide for air cooling and to prevent accidental contact with live conductors. Materials and final performance of the product must conform to applicable IEEE and NEMA standards. Transformer wiring compartment shall be located below the core and coil, and shall be cooled by air circulation, or the wiring compartment shall be insulated from the core and coil by means of a suitable thermal insulation barrier. All transformers shall be UL listed and shall bear the UL label.

F. Transformers shall operate, without cooling fans, at 100% nameplate KVA rating continuously while in a 40 degrees C ambient environment without exceeding the rated average winding temperature rise of the ANSI insulated system used. Specific KVA and voltage ratings required shall be as shown on the drawings. Transformers rated above 30 KVA shall have a 220 degrees C insulation system with 115 degrees C average temperature rise or 180 degrees C hot spot rise in a 40 degrees C ambient. Transformers rated 30 KVA and below shall have a 180 degrees C insulation system with 115 degrees C average temperature rise or 145 degrees C hot spot rise in a 40 degrees C ambient.

G. Sound levels must fall within ANSI-NEMA Standard levels according to KVA size.

H. Sound levels shall be warranted by the manufacturer not to exceed the following:

1. 15 to 50KVA - 45dB; 51 to 150kVA - 50dB; 151 to 300kVA - 55dB; 301 to 500kVA - 60dB; 501 to 700kVA - 62dB; 701 to 1000kVA - 64dB; 1001 to 1500kVA - 65dB; 1501 to 2000kVA- 66Db.

I. All transformers shall be supplied with clamp-type solderless connectors suitable for use with copper connecting cables.

J. All transformers shall have neoprene rubber pads between the core and coil assembly and the transformer enclosure to isolate sound and vibration. A flexible conduit connection to the transformer may be used.

K. Terminal boards shall be provided on all transformers. High-voltage and low-voltage terminals must be held in a fixed position, thus removing any need for taping of cable-terminal connections.

L. Transformers which weigh more than 50 pounds must have external lifting provisions for ease in handling.

M. Single phase transformers over 10 KVA and three-phase transformers 6 KVA and above shall have minimum full load rated taps in the high-voltage windings as follows: (6) 2-1/2% full

capacity taps, 3 above and 3 below normal rated voltage. Transformer taps shall be adjusted to deliver nominal system voltage at branch circuit panels.

3. EXECUTION

3.1 Install transformers as indicated in compliance with the manufacturers' written instructions, applicable requirements of the NEC, NEMA, ANSI and IEEE standards, and in accordance with recognized industry practices to ensure that products fulfill requirements.

3.2 Coordinate transformer installation work with electrical raceway and wire/cable work, as necessary for proper interface.

3.3 Install transformers on vibration mounts; comply with manufacturers recommended installation methods, if applicable.

3.4 Clearances shall be maintained around transformers in accordance with all applicable codes, standards and manufacturer's installation instructions.

END OF SECTION 26 22 00

SECTION 26 24 16 - PANELBOARDS

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract including General and Supplementary Conditions and Division 1 specification sections, apply to the work of this Section.

B. This Section is a Division 26 "Basic Materials and Methods" section, and is a part of each Division 26 section making reference to panelboards specified herein.

1.2 DESCRIPTION OF WORK

A. Extent of panelboard and enclosure work, including cabinets and cutout boxes is indicated on the drawings and by schedules.

B. Types of panelboards and enclosures in this Section include the following:

1. Distribution Panels
2. Lighting and Appliance Panels

C. Refer to other Division 26 sections for cable/wire, connectors and electric raceway work required in conjunction with panelboards and enclosures; not work of this Section.

1.3 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in the manufacture of panelboards and enclosures, of types, size and ratings required, whose products have been in satisfactory use in similar service for not less than five (5) years.

B. Installer: A firm of at least three (3) years of successful installation experience on projects with electrical installation work similar to that required for this project.

1.4 REFERENCES

A. Special Use Markings: Provide panelboards, constructed for special use, with UL markings indicating that special type usage. Panels identified or shown on the drawings for use as main service entrance equipment shall be labeled at the factory with "SERVICE ENTRANCE" type UL label.

B. UL Compliance: Comply with applicable UL safety standards pertaining to panelboards, accessories, and enclosures. Provide units which have been UL listed and labeled. UL standards are as follows:

1. Panelboards - UL67
2. Cabinets and Boxes - UL50

C. NEC Compliance: Comply with the NEC as applicable to the installation of panelboards, cabinets, and cutout boxes.

D. NEMA Compliance: Comply with NEMA Stds. Pub. No. 250 "Enclosures for Electrical Equipment (1000 volt maximum)", Pub. No. 1 "Panelboards" and Pub. No. PB1.1, "Instruction for Safe Installation, Operation, and Maintenance of Panelboards Rates 600 Volts and Less".

E. NECA Compliance: Comply with NECA's "Standard of Installation".

1.5 SUBMITTALS

A. Product Data: Submit manufacturer's data including specifications, installation instructions and general recommendations for each panelboard required. Include data substantiating that units comply with specified requirements.

B. Shop Drawings: Submit dimensioned drawings of panelboards and enclosures showing accurately scaled layouts of enclosures and required individual panelboard devices, including but not limited to circuit breakers, fusible switches, fuses, ground fault circuit interrupters, and accessories.

C. Shop Drawings shall be submitted along with, and at the same time as the Coordination Study and Arc Flash Hazard Analysis study described in specification section 260573. All submitted section 262416 equipment shall match the equipment in the Coordination Study and Arc Flash Hazard Analysis study.

2. PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with requirements provide products of one of the following:

1. Square D Company
2. General Electric
3. Cutler Hammer
4. Siemens

2.2 GENERAL

A. Except as otherwise indicated, provide panelboards, enclosures and ancillary components, of types, sizes, and ratings indicated, which comply with manufacturer's standard materials, and which are designed and constructed in accordance with published product information. Provide solderless lugs, or connectors, in the correct number and size for conductors on mains, on the load side of each branch, circuit, and on ground and neutral bars. Provide tin plated copper busses. Provide an insulated neutral bus and a bonded equipment ground bus mounted at the opposite end of the structure from the mains, and having numbered screw or lug terminals for connection of wires. Equip panels with the number of unit devices as required for a complete installation. Where more than one type of component meets the indicated requirements, selection is installer's option. Where types, sizes or ratings are not indicated, comply with NEC, UL and established industry standards for applications indicated.

B. Provide ground fault circuit interrupting type circuit breakers for all devices noted with a "GFI" subscript on the panelboard schedules for this project.

C. Provide UL listed HACR type circuit breakers for all devices which serve heating, ventilating, or air conditioning equipment.

D. Panelboards shall be provided with covers for surface or flush mounting as shown on the drawings, or as required for actual project conditions.

E. Panelboards shall be constructed for top or bottom feeder service, as required by actual project conditions.

F. All circuit breaker trip indications and metered values shall be displayed on the front of the panelboard after opening the hinged door without removal of any bolted covers.

2.3 LIGHTING AND APPLIANCE PANELS

A. Lighting and appliance panelboards shall be Square D type NQOB (or equal) 120/208 volt applications. All branch circuit breakers are to be quick-make, quick-break, trip indicating and common trip on all multi-pole breakers, and shall be bolt-on type. Plug in breakers are not allowed. Trip indication shall be clearly shown by breaker handle located between the "ON" and the "OFF" positions. Panelboards shall have distributed phase copper bussing throughout.

B. Review drawings and provide main circuit breaker type panels where indicated on the drawings. Additionally, provide main lug only type panels where indicated on the drawings.

C. Provide fully rated main circuit breaker or main lug only (see drawings) type panelboards where the short circuit rating of the complete panelboard assembly is determined by the lowest rated branch device. Provide panelboard interrupting ratings as noted on the drawings.

D. Lighting and appliance panels shall be 5.75” deep, maximum and shall have 6-inch minimum gutters. Fronts are to be complete with door in door hinge style and cylinder lock, with all locks

keyed alike. Fronts shall have adjustable trim clamps, directory frames, and shall be equipped with a typewritten directory that identifies each circuit breaker by number and the equipment that the breaker serves. One additional blank directory card for each panel shall be furnished to the Owner.

E. Two section panels (as required by Code) shall be equipped with boxes of equal dimensions.

F. Panelboards shall be Underwriters' Laboratory listed and shall bear the UL label. The size of the panelboard main disconnect device or main lugs, the rating and number of branch circuits, and the type of mounting shall be as shown on the drawings.

G. All factory installed devices shall be re-torqued prior to energizing.

2.4 DISTRIBUTION PANELS

A. Distribution panels shall be Square D I-Line (or equal) panels as indicated on the plans. Provide appropriate type of panels to meet specific project requirements. Panelboards shall have distributed phase copper bussing throughout.

B. Circuit breakers shall be as specified for lighting panels unless indicated otherwise. Power panels shall have combination card holder and name-plate and shall be equipped with typewritten directories that identify all loads served and all spare circuits. Provide a copper ground bus in all power panels.

C. Power panels shall be Underwriters' Laboratory approved and shall bear the UL label. Main lugs and gutters shall be suitable for copper and aluminum wire. The size of the panelboard main protective device or main lugs, the size, type and the number of branch circuits and the type of mounting shall be as shown on the drawings.

D. Review drawings and provide main circuit breaker type panels where indicated on the drawings. Additionally, provide main lug only type panels where indicated on the drawings.

E. Provide fully rated main circuit breaker or main lug only (see drawings) type panelboards where the short circuit rating of the complete panelboard assembly is determined by the lowest rated branch device. Provide panelboard interrupting ratings as noted on the drawings.

2.5 FEEDER PROTECTIVE DEVICES

1. The following paragraphs list the general feeder protective device requirements:

   a. Feeder protective devices as shown shall be molded case air circuit breakers, built, tested and UL labeled per UL 489.
   b. In general breakers with 200 ampere frames and above shall be Square D Powerpact or approved equivalent with solid-state trip complete with built in current

transformers, solid-state trip unit and flux transfer shunt trip. Breaker shall include a true RMS sensing electronic trip unit with; adjustable long time pickup, adjustable long time delay, adjustable short time pickup, adjustable short time delay, I2tin and I2tout, adjustable instantaneous pickup, and targets to show cause of breaker trip. Where ground fault trip function is used it shall be part of the circuit breaker electronic trip unit and include; adjustable pickup, adjustable delay, I2tin and I2tout

c. Solid state instantaneous element shall be continuously adjustable from approximately 4 to 8 times the trip rating, with short time adjustment from instantaneous to 10-cycle delay for coordination purposes. Provide short delay override feature providing for instantaneous tripping on high magnitude faults.

d. Molded case breakers shall have a minimum UL listed interrupting capacity as listed on the drawings.

e. For all circuit breakers rated 1200 Amps or more, provide circuit breaker with an energy reducing maintenance switch per NEC paragraph 240.87. Maintenance switch shall be a two position, lockable device with a locally mounted blue strobe beacon enabled when in maintenance mode. System shall have one spare set of contacts for future use. A label shall be provided for beacon stating “Breaker in Maintenance Mode When Flashing”. Alternative methods may be considered on a case by case basis.

2.6 CUSTOMER METERING

A. Where indicated on the drawings, provide digital electronic power meters with the following monitoring and metering capabilities:

1. Current, per phase and neutral.
2. Voltage, phase-to-phase and phase-to neutral.
3. Real power (kW), per phase and three-phase total.
4. Reactive power (kVAR), per phase and three phase total.
5. Apparent power (kVA), per phase and three phase total.
6. Power factor (true), per phase and three phase total.
7. Frequency.
8. Demand current, per phase and neutral, present and peak.
9. Real power demand (kWd), three phase total, present and peak.
10. Reactive power demand (kVARd), three phase total, present and peak.
11. Apparent power demand (kVAd), three phase total, present and peak.
12. Real energy (kWh), three phase total.
13. Reactive energy (kVARh), three phase total.
14. Apparent energy (kVAh) three phase total.
15. Energy accumulation modes, signed, absolute, energy in, energy out.
16. Total harmonic distortion (THD), voltage and current, per phase.
17. Date and time stamping, peak demands, power up/restart and resets.

A. Provide all necessary components and connections from electronic power meter to Owner’s Building Management System. Coordinate requirements and installation with the Owner’s control representatives.

B. The power meter shall be accurate to 0.25% of the reading plus 0.05% of the full scale for voltage and current sensing, and 0.5% of the reading plus 0.05% of the full scale for power and energy, accurate through the 31st harmonic.

C. Provide necessary current transformers to support current inputs to the power meter. Provide potential transformers, control power transformers, and fusing as required.

3. EXECUTION

3.1 INSTALLATION

A. General: Install panelboards and enclosures where indicated, in accordance with the manufacturers' written instructions, applicable requirements of the NEC and NECA's "Standard of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.

B. Coordinate the installation of panelboards and enclosures with cable and raceway installation work.

C. Provide all required electrical connections within the enclosure.

D. Fill out typewritten panelboard circuit directory cards upon completion of the installation work.

END OF SECTION 26 24 16

(INCLUDED AS PART OF ADD ALTERNATE #2)

SECTION 26 25 50 – DUAL PURPOSE DOCKING STATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections apply to the work of this Section.

B. Division 26 "Basic Materials and Methods" sections apply to the work in this Section.

1.2 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ETL/UL LISTED to 1008 Standards

C. UL 50 LISTED.

D. Comply with NFPA 70.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's data including specifications, installation instructions, one line diagram, wiring diagram(s), and general recommendations for required dual purpose docking station.

1.4 GUARANTEE/WARRANTY

A. The equipment installed under this contract shall be left in proper working order.

B. New materials and equipment shall be guaranteed against defects in composition, design or workmanship. Guarantee certificates shall be furnished.

PART 2. PRODUCTS

2.1 GENERATOR DOCKING STATION

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. TRYSTAR: Dual Purpose Generator Docking Station, DBDS-5

   Or Equivalent by

2. ESL Power Systems
3. ASCO

2.2 GENERAL REQUIREMENTS

A. Docking station shall include 16 Series Camlok Panel Mounts for use as connection to Portable Generator and Temporary Load Bank

B. Entire package must be listed to ETL or UL 1008 Standards. UL listing of individual components is not acceptable.

C. Enclosures:

1. NEMA 3R rain-tight, Aluminum or 304 Stainless Steel

   a. Pad-lockable front door shall include a hinged access plate at the bottom for entry of cables from portable generator or portable load bank. NEMA 3R integrity shall
   b. be maintained with access plate open for cable entry.
   c. Front and side through a front access panel shall be accessible for maintenance.
   d. Top, side, and bottom through a front access panel shall be accessible for permanent cabling.

2. Finishes:

   a. Paint after fabrication. Powder coated Hammertone Gray.

D. Phase, Neutral, and Ground Buses:

1. Material: Silver-plated Copper
2. Equipment Ground Bus: bonded to box.
3. Isolated Ground Bus: insulated from box.
4. Ground Bus: 50% of phase size.
5. Neutral Bus: Neutral bus rated 100 percent of phase bus.
6. Round edges on bus.

E. Temporary generator connectors shall be Camlok style mounted on gland plate.

1. Camlok shall be color coded according to system voltage

   a. A phase – Black or Brown

b. B phase – Red or Orange
c. C phase – Blue or Yellow
d. N Neutral – White
e. G Ground – Green

F. Temporary load bank connectors shall be Camlok style mounted on gland plate.

1. Camlok shall be color coded according to system voltage

a. A phase – Black or Brown
b. B phase – Red or Orange
c. C phase – Blue or Yellow
d. G Ground – Green

G. Temporary connectors shall include protective flip lids to prevent accidental contact.

H. Permanent connectors shall be broad range set-screw type, located behind an aluminum barrier.

I. Short Circuit & Withstand Rating

1. Shall be minimum 65KAIC unless otherwise indicated on drawings.

J. Voltage & Amperage:

1. 480Y/277V, 3Ph and amperage as indicated on drawings.

K. Phase Rotation Monitor Device:

1. Phase monitoring relay to be Siemens 3U4512-1AR20 or equal.

L. Optional Breaker Disconnects as Indicated on Project Drawings and Manufacturer Submittal Drawings:

1. Must be UL 489 Listed Breaker
2. Breakers shall be removable for service and maintenance

M. Additional accessories shall be included in submittal drawings as follows:

1. Battery Charger Receptacle 20A, GFCI 125V
2. Kirk Key Door Interlock

PART 3. EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive Generator Docking Station for compliance with installation tolerances and other conditions affecting performance of the Work.

3.2 INSTALLATION

A. Surface, Flush or Base Mounted: Determined by Application

1. Install anchor bolts to elevations required for proper attachment to Generator Docking Station.

3.3 FIELD QUALITY CONTROL

A. Third Party Tests and Inspections to include the following:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

B. Prepare test and inspection reports, including a certified report that identifies Generator Docking Station and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 26 25 50

SECTION 26 27 26 - WIRING DEVICES

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this Section.

B. This section is a Division 26 "Basic Materials and Methods" section, and is a part of each Division 26 section making reference to wiring devices specified herein.

1.2 DESCRIPTION OF WORK

A. The extent of wiring device work is indicated by drawings and schedules. Wiring devices are defined as single discrete units of electrical distribution systems which are intended to carry, but not utilize electrical energy.

B. Types of electrical wiring devices in this Section include the following:

1. Receptacles
2. Switches
3. Wall Plates
4. Dimmer Controls

1.3 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in manufacture of wiring devices of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less then 3 years.

B. Installer: Qualified with at least 2 years of successful installation experience on projects with electrical installation work similar to that required for this project.

1.4 REFERENCES

A. NEC Compliance: Comply with NEC as applicable to construction and installation of electrical wiring devices.

B. UL Compliance and Labeling: Provide electrical wiring devices which have been UL listed and labeled.

C. NEMA Compliance: Comply with NEMA standards for general and specific purpose wiring devices.

D. NECA Compliance: Comply with NECA's "Standard of Installation."

1.5 SUBMITTALS

A. Product Data: Submit manufacturer's data on electrical wiring devices.

2. PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products of one of the following:

1. Pass and Seymour Corporation
2. Cooper
3. Hubbell, Inc.
4. Leviton, Inc.
5. Crouse Hinds
6. Lutron

2.2 WIRING DEVICES

A. General: Where shown on the drawings, furnish and install wiring devices indicated by the appropriate symbols. Unless otherwise noted, wiring devices shall be products of Pass and Seymour Corporation, or equal. Catalog numbers shown below are P & S hard use specification grade. Similar devices manufactured by Hubbell or Leviton shall be equally acceptable.

B. Switches: Branch circuit switches shall be flush tumbler type as follows:

1.	Single Pole	CSB20AC1 Series - Gray
2.	Two Pole	CSB20AC2 Series - Gray
3.	Three-Way	CSB20AC3 Series - Gray
4.	Four-Way	CSB20AC4 Series - Gray
5.	Single Pole SW With Pilot	CSB20-AC1-RPL Series

6. LED Dimmer Switches: Provide dimmer switches capable of 0-10 Volt dimming of LED and fluorescent loads, Legrand Radiant series or engineer approved equal. Provide adequate number of conductors between dimmer switches and dimmed fixtures regardless of circuiting shown on drawings.
7. Switches fed by a generator circuit (standby or life safety) shall be the same as above but RED in color.
8. Where specific wiring devices are indicated on the drawings the device indicated on the drawings shall govern.

A. Occupancy Sensors/Switches, Time Switches, Lighting Control System

1. Reference Drawings for additional information.
2. All switches shall be gray in color if fed from a non-emergency panelboard. Switches fed by a generator circuit shall be RED in color.

2.3 RECEPTACLES

A. All receptacles shall be side and back wired, self-grounding of the type indicated on the drawings, or as follows. Catalog numbers shown below are Pass & Seymour specification grade unless otherwise indicated. Similar devices manufactured by Hubbell or Leviton shall be equally acceptable:

1.	Duplex Convenience Receptacles 20A-125V (Grounding Type)	CRB5362 Series-Gray
2.	Weatherproof Duplex Receptacles 20A-125V (Grounding Type)	CRB5362-Gray-WP Series- with Weatherproof Plate
3.	Duplex GFI Receptacle 20A-125V	2095 Series-Gray
4.	Weatherproof Duplex GFI Receptacle 20A-125 Volt	2097TRWR-Gray with WP Wall Plate
5.	Duplex USB Receptacle	TR5362USB-Gray
6.	Tamper Resistance Receptacle	TR63-Gray for Normal

7. All receptacles fed by a generator circuit shall be the same as above but RED in color.

2.4 PLATES

A. Furnish and install wall plates for all wiring devices. Where switches and/or receptacles are shown adjacent to each other, provide a common cover plate for each group of devices. Oversize plates are not acceptable.

1. Plates shall be Pass and Seymour Type 302 stainless steel.
2. Cover plates for all electrical devices shall be engraved with panel and circuit no. designation. Engraving shall be 1/8” high, block style letters, with black filler on front side of cover plates.
3. Weatherproof switch plates shall be Crouse Hinds DS185 type.
4. Weatherproof receptacle plates shall be Crouse Hinds WLRD1 type.
5. Weatherproof “In-Use” receptacle plates shall be Intermatic Extra-Duty Die-Cast Aluminum Series. Provide necessary number of gangs, mounting bases, inserts and gaskets. In-use covers shall be used in all wet location areas as defined by NEC 406.9(B)(1).

3. EXECUTION

3.1 INSTALLATION

A. Install wiring devices as indicated in compliance with manufacturer's written instructions, applicable requirements of the NEC and NECA's "Standard of Installation," and in accordance with recognized industry practices to fulfill project requirements.

B. Coordinate with other work including painting, electrical boxes and wiring work, as necessary to interface installation of wiring devices and other work.

C. Testing: Test wiring devices for electrical continuity of grounding connections and proper polarity. Test wiring devices to demonstrate compliance with requirements.

D. Where devices are installed on exposed fittings or boxes, the plates shall be galvanized and of a type designed to fit the box. Blank covers shall be installed on all boxes without devices or fixtures, of same type as installed on devices in the room or area.

E. All outlets shall be located as shown on the drawings, except that where practicable, outlets shall be located in center of panels or trim or otherwise symmetrically located to conform with existing structural layout. Outlets incorrectly installed shall be corrected. Damaged items or damaged finishes shall be repaired or replaced at no expense to the Owner.

F. Outlets shall be set plumb or horizontal and shall extend to the finished surface of the walls, ceiling or floor, as the case may be, without projecting beyond the same.

G. Receptacles, switches, etc., shown on wood trim, cases or other fixtures shall be installed symmetrically; and, where necessary, shall be set with the long dimensions of the plate horizontal, or ganged in tandem.

H. Where dimmer switches are shown adjacent to standard switches, both shall be installed in separate back boxes with adequate space between so that neither cover plate requires cutting.

I. Where devices are shown near wall openings, coordinate location if corner guards are to be installed so that cover plates do not require cutting.

J. Where devices are shown mounted adjacent to one another on the drawings, provide multi-gang faceplates to cover all devices.

END OF SECTION 26 27 26

SECTION 26 29 13 - MOTOR CONTROLLERS

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to the work of this Section.

B. Division 26 "Basic Electrical Materials and Methods" section apply to the work specified in this Section.

C. Control Devices: Division 23 control devices such as aquastats, electric-pneumatic and pneumatic-electric switches, thermostats, freezestats, etc. are furnished and connected by the Division 23 Contractor unless specifically noted otherwise.

D. Motors: All motors shown on the drawings shall be furnished and set in place under the specific section in which the motor is specified.

E. Motor starters specified in other sections of this specification such as Division 23 shall be provided with power wiring by the Division 26 Contractor.

1.2 DESCRIPTION OF WORK

A. Extent of motor starter work is indicated by drawings and schedules.

B. Type of motor starters specified in this Section are as follows:

1. Full Voltage Non-Reversing Magnetic Starters
2. Reduced Voltage Starters
3. Manual Motor Starters
4. Remote Controls

1.3 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in the manufacture of motor starters of types, ratings and characteristics required, whose products have been in satisfactory operation in similar service for not less than five (5) years.

B. Firm with at least three (3) years of successful installation experience on projects utilizing motor starters similar to that required for this project.

1.4 REFERENCES

A. NEC Compliance: Comply with NEC requirements as applicable to wiring methods, construction, and installation of motor starters.

B. NFPA Compliance: Comply with applicable requirements of NFPA standard 70E "Standard for Electrical Safety Requirements for Employee Workplaces."

C. UL Compliance: Comply with applicable requirements of UL 486A "Wire, Connectors, and Soldering Lugs for Use with Copper Connectors," and UL 508 "Electrical Industrial Control Equipment" pertaining to the installation of motor starters. Provide motor starters and components which are UL listed and labeled.

D. IEEE Compliance: Comply with applicable requirements of IEEE Standard 241 "Recommended Practice for Electric Power Systems in Commercial Buildings" pertaining to motor starters.

E. NEMA Compliance: Comply with applicable requirements of NEMA Standard ICS 2, "Industrial Control Devices, Controllers and Assemblies," and Pub. No. 250, "Enclosures for Electrical Equipment (1000 volts Maximum)" pertaining to motor controllers/starters and enclosures.

1.5 SUBMITTALS

A. Product Data: Submit manufacturer's data on motor starters.

B. Provide shop drawings of equipment being provided and control diagrams for each motor starter.

2. PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the requirements, provide motor starters of one of the following:

1. Allen Bradley Co.
2. General Electric Co.
3. Siemens
4. Square D Co.

2.2 GENERAL

A. Except as otherwise indicated, provided motor starters and ancillary components which comply with the manufacturer's standard materials, and which are designed and constructed in accordance with published product information as required for a complete installation. Unless specifically indicated otherwise provide all power wiring, disconnects, starters, relays, hand-off-auto switches, pilot lights, motor connections, supports and all miscellaneous and necessary appurtenances required for a satisfactory and complete working system.

B. All devices in Animal Areas shall be NEMA 4/4X rated. Other locations shall have enclosure ratings as stated in this specification.

2.3 FULL VOLTAGE NON-REVERSING MAGNETIC STARTERS

A. Provide magnetic starters for three phase motors. Motor starters shall be full voltage non-reversing across the line magnetic type rated in accordance with NEMA standard sizes and horsepower ratings. Magnetic starters shall not be less then NEMA size one.

1. Each starter shall have a removable hinged cover capable of being padlocked. Enclosures shall be NEMA 1 general purpose type unless indicated otherwise. Provide watertight and dust tight enclosures for units installed outside, or as indicated on the drawings. Starters shall be provided with double break silver alloy contacts. All contacts shall be replaceable without removing wiring or the starter from the enclosure.

B. Magnetic starters shall be provided with the following additional equipment:

1. Overload relays shall be an integral part of the motor starter. Overload relays shall have a minimum ±10 percent adjustment from the nominal heater rating. Heaters shall be available such that when used with the ±10 percent adjustment, a continuous selection of motor full load currents can be obtained through the size limitations of the starter. Overload relays shall be manual reset and field convertible from manual to automatic reset. Overload relays shall be melting alloy or bimetallic type. Thermal units shall be of one piece construction and interchangeable. The starter unit shall be inoperative if the thermal unit is removed. Provide 3 overload relays, one for each phase of the three phase starter.
2. Starters shall be suitable for the addition of at least three normally open and three normally closed auxiliary contacts. Provide a minimum of two normally open and two normally closed contacts unless additional contacts are scheduled on the drawings or required for proper control of the equipment.
3. In each magnetic starter provide cover mounted hand-off-auto selector switch complete with a manual overload reset button and a red "On" pilot light. Provide a control transformer with a secondary voltage of 120V, complete with primary overload and short circuit protection.
4. Time delay relays with time delay after energization shall be provided for starters indicated, or as required for proper control of equipment. Time delay feature shall be adjustable from 0 to 60 seconds and set as indicated on the drawings.

2.4 PART WINDING REDUCED VOLTAGE MANETIC STARTERS

A. Provide Allen-Bradley Bulletin 736 part-winding starters, closed-transition, magnetic, non-reversing, reduced-inrush, two-step type. Limit line current to a maximum of 65 percent of the locker rotor current. Coordinate and verify compatibility with the motor and driven equipment. Provide starter capable of interrupting 10 times motor full load rating.

B. Provide starters with the equipment listed in paragraph 2.3, B above.

C. Provide additional equipment for combination starters in accordance with paragraph 2.3, B above.

2.5 WYE-DELTA REDUCED VOLTAGE MAGNETIC STARTERS

A. Provide Allen-Bradley Bulletin 737 wye-delta starters, magnetic, non-reversing, reduced-inrush, closed-circuit transition type. Limit the inrush line current to a maximum of 35 percent of the locked rotor current. Coordinate and certify compatibility with the motor and driven equipment. Provide three thermal overload relays in series with each winding. Provide starter capable of interrupting 10 times motor full local rating.

B. Provide starters with the equipment listed in paragraph 2.3, B above.

2.6 AUTO-TRANSFORMER REDUCED VOLTAGE MAGNETIC STARTERS

A. Provide Allen-Bradley Bulletin 746 auto-Transformer starters, magnetic, non-reversing, reduced-inrush, closed-circuit transition type. Provide minimum tap of 65 percent for motors 30 hp or less, and 50 percent for motors in excess of 30 hp. Limit the inrush line current to a maximum of 43 percent and 25 percent respectively, of the locked rotor current. Provide thermal overload protection in each phase. Provide starter capable of interrupting 10 times motor full load rating.

B. Provide starters with the equipment listed in paragraph 2.3, B above.

2.7 FULL VOLTAGE NON-REVERSING COMBINATION STARTERS

A. Full voltage non-reversing combination starters shall be Square D Class 8538 (or equal) unless otherwise indicated. Provide additional equipment for combination starters in accordance with the requirements outlined in paragraph 2.3.2 above. Where combination starters are shown on the drawings, a separate starter and disconnect switch may be substituted at the Contractor's option, provided adequate space is available for the installation.

B. Provide fused disconnect switches with Class R type fuse rejection clips. If breakers are shown, provide breakers with a minimum of 22,000 RMS symmetrical amps interrupting capacity.

2.8 MANUAL MOTOR STARTERS

A. Thermal element type manual motor starters complete with melting alloy type thermal overload relays for single phase motors shall be Square D Class 2510. Provide overload relays sized in accordance with NEC requirements for the motor loads served.

B. Provide flush mounted units in finished areas and surface mounted units in unfinished areas. Starter shall have NEMA I general purpose enclosure, unless otherwise indicated, and be rated for the motor horsepower required.

2.9 REMOTE CONTROLS

A. Provide Square D standard duty oil-tight pushbuttons, pilot lights, and/or selector switches where indicated on the drawings, or wherever required for proper control of the equipment. Units shall be flush mounted in finished areas and surface mounted in unfinished areas.

3. EXECUTION

3.1 INSTALLATION

A. Install motor starters as indicated, in accordance with equipment manufacturer's written instructions and with recognized industry practices; complying with applicable requirements of the NEC, UL and NEMA Standards, to ensure that products fulfill requirements.

B. Coordinate with other work including motor and electrical wiring/cabling work as necessary to interface installation of motor starters with other work.

C. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Std. 486A.

D. Install fuses in fusible disconnect switches as required.

E. Adjusting and Cleaning: Inspect electrical starter's operating mechanisms for malfunctioning and, where necessary, adjust units for free mechanical movements.

F. Field Quality Control: Subsequent to connecting wire/cables, energize motor starter circuitry and demonstrate functioning of equipment in accordance with specified requirements. Where necessary, correct malfunctioning units and retest to demonstrate compliance. Ensure that direction of rotation of each motor fulfills requirements.

END OF SECTION 26 29 13

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SECTION 26 29 23
VARIABLE FREQUENCY DRIVES

1. GENERAL

1.1 SECTION INCLUDES

A. Variable Frequency Drives for use on mechanical equipment including fans and pumps.

B. Exact horsepower and voltage requirements are as shown the Mechanical Equipment Schedules on the drawings.

C. The Contractor shall provide all labor, materials, tools, and equipment required to furnish, construct, and install motor starters, electrical power circuits, and other items and equipment as detailed on the Drawings and specified herein.

D. The Work shall include everything requisite and necessary to finish the Work properly, notwithstanding that every item of labor or materials or accessories required to make the installation complete may not be specifically mentioned.

E. The Work shall include, but shall not necessarily be limited to, the following:

1. Furnish and install VFDs as indicated on the Drawings.

1.2 REFERENCES.

A. NEMA ICS 7.1 - Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable Speed Drive Systems; National Electrical Manufacturers Association.

B. NEMA ICS 7 - Industrial Control and Systems: Adjustable Speed Drives; National Electrical Manufacturers Association.

C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); National Electrical Manufacturers Association.

D. NETA STD ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems; International Electrical Testing Association.

E. Institute of Electrical and Electronic Engineers (IEEE) Standard 519-1992, IEEE Guide for Harmonic Content and Control.

F. Underwriters laboratories UL508C

G. IEC 16800 Parts 1 and 2

H. NFPA 70 - National Electrical Code; National Fire Protection Association.

1.3 SUBMITTALS.

A. Product Data: Provide catalog sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.

B. Shop Drawings: Indicate front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.

C. Test Reports: Indicate field test and inspection procedures and test results.

D. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

E. Manufacturer's Field Reports: Indicate start-up inspection findings.

F. Operation Data: NEMA ICS 7.1. Include instructions for starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions.

G. Maintenance Data: NEMA ICS 7.1. Include routine preventive maintenance schedule.

H. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to mechanical equipment. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

I. Compliance to IEEE 519 – harmonic analysis for particular jobsite including total harmonic voltage distortion and total harmonic current distortion (TDD).

1. The VFD manufacturer shall provide calculations; specific to this installation, showing total harmonic voltage distortion is less than 5%. Input filters shall be sized and provided as required by the VFD manufacturer to ensure compliance with IEEE standard 519. All VFD’s shall include a minimum of 5% impedance reactors, no exceptions.

1.4 OPERATION AND MAINTENANCE DATA.

A. The manufacturer shall supply test results to confirm that the controller has been tested to substantiate designs according to applicable ANSI and NEMA standards. These tests shall verify not only the performance of the unit and integrated assembly, but also the suitability of the

enclosure venting and rigidity. In addition, unit shall be factory tested in accordance with ANSI standards. Manufacturer shall provide factory test report to be included with the operation and maintenance manuals shipped with the unit.

1.5 QUALIFICATIONS.

A. Conform to requirements of NFPA 70.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum five years documented experience and with service facilities within 200 miles of Project.

C. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.6 MAINTENANCE SERVICE.

A. Provide service and maintenance of controllers for one year from Date of Substantial Completion.

1.7 REGULATORY REQUIREMENTS.

A. Conform to requirements of NFPA 70.

B. Furnish products listed and classified by Underwriters Laboratories, Inc.

C. FM P7825 - Approval Guide; Factory Mutual Research Corporation.

D. NEMA MG 1 - Motors and Generators; National Electrical Manufacturers Association.

E. SSPC-Paint 15 - Steel Joist Shop Paint; Society for Protective Coatings (Part of Steel Structures Painting Manual, Vol. Two).

1.8 DELIVERY, STORAGE, AND HANDLING.

A. See Section 23 05 00.

B. 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.

C. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to components, enclosure, and finish.

2. PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers of variable frequency drives shall be limited to the following:

1. ABB Model ACH580
2. Toshiba Model Q9 Plus
3. Yaskawa Model HV600
4. Or approved equivalent. **Any other manufacturer must be submitted during bidding process. Provide list of differences between proposed manufacturer's equipment and equipment as specified.**

2.2 VARIABLE FREQUENCY DRIVES (VFDs)

A. Variable Frequency Controllers: Enclosed controllers suitable for operating the indicated loads, in conformance with requirements of NEMA ICS 7. Select unspecified features and options in accordance with NEMA ICS 3.1.

1. Employ microprocessor-based inverter logic isolated from power circuits.
2. Employ pulse-width-modulated inverter system.
3. Include a DC link reactor for reduction of harmonic distortion.
4. The controller, and all associated components, shall be supplied by a single vendor.
5. The controller will be operating a variable volume fan motor, or water pump motor for HVAC application.
6. System voltage shall be indicated on front of ASD, using minimum of 1-inch high letters.

B. Enclosures: NEMA 250, Type 1, suitable for equipment application in places regularly open to the public. No disconnects in VFD cabinet. Disconnect must be in separate enclosure.

2.3 OPERATING REQUIREMENTS

A. Rated Input Voltage for motors rated below 40 HP: 200 volts, three phase, 60 Hertz, with a voltage tolerance of +/- 10% and a frequency tolerance of +/- 2 Hz.

B. Rated Output: Output frequency shall vary between 0.1 Hz and 400 Hz. Frequency resolution shall be 0.01 Hz digital and 0.03 Hz analog with an accuracy of +/-0.2% of maximum frequency at 25 degrees Celsius. Maximum voltage frequency shall be adjustable from 25 Hz to 400 Hz. Voltage boost shall be adjustable from 0% to 30% with starting frequency adjustable from 0 Hz to 10 Hz. The output current shall be 100% continuous and 110% for 60 seconds, based on NEC table 430-150 (Full-Load Current, Three-Phase Alternating Current Motors) for 200 volts or 460 volts.

C. The controller shall contain three critical frequency jump points with individual bandwidth. Upper and lower frequency limits shall be capable of being varied.

D. The PWM carrier frequency shall be adjustable from 5000 Hz to 15000 Hz.

E. The drive shall contain two separate acceleration/deceleration times (0.1 to 6000 seconds) with a choice of linear, S, or C curves. The drive shall have a standard dynamic electric braking for motors rated 30 HP or below. The drive shall restart into a rotating motor by sensing the coasting motor speed and matching that frequency. The drive shall have adjustable soft stall (10%-150%) and adjustable electronic overload protection (10%-100%).

F. The drive shall have external fault input, be capable of re-setting faults remotely and locally.

G. Input Signal:

1. 0 to 10 v DC
2. 0 to 5 v DC
3. 4 to 20 mA DC

H. Manual bypass is not required on VFD unless indicated on bid documents.

2.4 COMPONENTS

A. Display: Provide integral digital display to indicate output voltage, output frequency, and output current, output power (kw), and motor RPM.

2.5 HARMONICS

A. Reference IEEE 519-2014 Total Demand Distortion (TDD) limit at the PCC (point of common coupling). VFD supplier must provide harmonic calculations to show compliance with IEEE 519-2014.

B. VFDs provided shall have 5% reactor (or DC choke) as integral to the VFD.

C. Additional harmonic mitigation equipment in order to achieve compliance with IEEE 519-2014 shall include, but not be limited to, the following:

1. 5% THD passive harmonic filter with contactor. The passive harmonic filter shall be mounted in the same enclosure as the drive.
2. A capacitor drop-out contactor shall be included to open at reduced loads.

D. Active front end “ULH” technology the incorporates DC bus capacitors, IGBTs, LCL filtering, and LCL contactor. Maintain unity power factor at full load while complying with IEEE 519-2014. VFDs that do not utilize this technology are not allowed.

E. VFDs that cannot produce an output voltage that is equal to the motor nameplate voltage while operating at full speed are not allowed

3. EXECUTION

3.1 INSTALLATION

A. Install in accordance with NEMA ICS 7.1, manufacturer's instructions, and per drawings.

B. Tighten accessible connections and mechanical fasteners after placing controller.

C. Provide engraved plastic nameplates; refer to Division 26 for product requirements and location.

D. Neatly type label inside each motor controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating. Place in clear plastic holder.

E. When remote service disconnect is required, provide with auxiliary contacts hardwired to VFD safety circuit to shut down VFD, if disconnect is opened.

F. Install units on floor mounted uni-strut frames or on housekeeping pads (pads to be used for larger, free standing units only).

G. Do not install units such that their supports or the units themselves are in direct contact with vibrating equipment (i.e., fans, pumps, compressors, etc.).

H. Do not install units directly below mechanical piping, expansion tanks, etc.

I. The service disconnect switch must be installed on the line side of the VFD. The disconnect must be in a separate enclosure from the VFD. If conditions do not allow this disconnect to be located near the motor within NEC requirements, then a second remote disconnect may be required at the motor. Consult the project manager or University Engineer if this condition arises. All remote disconnects must be provided with auxiliary contacts hardwired to VFD safety circuit to shut down VFD when disconnect is opened. This may affect warranty on the drive so every attempt should be taken to install it per these design guidelines.

J. If a single VFD is controlling multiple fans in an air handling unit then overload protection on each fan must be provided. No more than 4 fans shall be connected to a single VFD.

K. The ground wire should be of the same size as the power conductors from the motor to the VFD and from the VFD to the source.

3.2 PRODUCT SUPPORT

A. Factory trained application engineering and service personnel that are thoroughly familiar with the VFD products offered shall be locally available at both the specifying and installation locations. A toll free 24/365 technical support line shall be available.

B. A computer based training shall be provided to the owner at the time of project closeout. The training shall include installation, programming and operation of the VFD, bypass and serial communication.

3.3 FIELD QUALITY CONTROL

A. Prior to initial energization, provide the service of the manufacturer's field representative to prepare and start controllers

3.4 WARRANTY

A. Manufacturer shall guarantee in writing one (2) years on site parts and labor warranty.

3.5 MAINTENANCE

A. Furnish two extra of each air filter.

B. Provide service and maintenance of controllers for one year from Date of Substantial Completion

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(INCLUDED AS PART OF ADD ALTERNATE #2)

SECTION 26 32 13 – ELECTRICAL EMERGENCY STANDBY POWER SYSTEM GENERATOR SET

1. GENERAL

1.1 SCOPE

A. Provide complete factory assembled generator set equipment with digital (microprocessor-based) electronic generator set controls, digital governor, and digital voltage regulator.

B. Provide factory test, startup by a supplier authorized by the equipment manufacturer(s), and on-site testing of the system.

C. The generator set manufacturer shall warrant all equipment provided under this section, whether or not is manufactured by the generator set manufacturer, so that there is one source for warranty and product service. Technicians specifically trained and certified by the manufacturer to support the product and employed by the generator set supplier shall service the generator sets.

1.2 CODES AND STANDARDS

A. The generator set installation and on-site testing shall conform to the requirements of the following codes and standards, as applicable. The generator set shall include necessary features to meet the requirements of these standards.

1. IEEE446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
2. NFPA37 – Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
3. NFPA70 – National Electrical Code. Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702.
4. NFPA99 – Essential Electrical Systems for Health Care Facilities
5. NFPA110 – Emergency and Standby Power Systems. The generator set shall meet all requirements for Level 1 systems. Level 1 prototype tests required by this standard shall have been performed on a complete and functional unit, component level type tests will not substitute for this requirement.

B. The generator set and supplied accessories shall meet the requirements of the following standards:

1. NEMA MG1-1998 part 32. Alternator shall comply with the requirements of this standard.
2. UL142 – Sub-base Tanks
3. UL1236 – Battery Chargers
4. UL2200. The generator set shall be listed to UL2200 or submit to an independent third party certification process to verify compliance as installed.

C. The control system for the generator set shall comply with the following requirements.

1. EN50082-2, Electromagnetic Compatibility – Generic Immunity Requirements, Part 2: Industrial.
2. EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
3. FCC Part 15, Subpart B.
4. IEC8528 part 4. Control Systems for Generator Sets
5. IEC Std 801.2, 801.3, and 801.5 for susceptibility, conducted, and radiated electromagnetic emissions.
6. UL508. The entire control system of the generator set shall be UL508 listed and labeled.
7. UL1236 –Battery Chargers.

D. The generator set manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.

1.3 ACCEPTABLE MANUFACTURERS

A. Only approved bidders shall supply equipment provided under this contract. Equipment specifications for this project are based on generator sets manufactured by Cummins Power Generation with microprocessor-based controls. Equivalent systems and equipment provided by, Kohler, Caterpillar, MTU or Generac are acceptable. Equipment by other suppliers that meets the requirement of this specification is acceptable, if approved not less than 10 days before scheduled bid date. Proposals must include a line by line compliance statement based on this specification.

2. PRODUCTS

2.1 GENERATOR SET

A. Ratings

1. The generator set shall operate at 1800 rpm and at a voltage of: **480** Volts AC, Three phase, 4-wire, 60 hertz.
2. The generator set shall be rated at **300 kW, 375 kVA** at 0.8 PF, Standby rating, based on site conditions of: Altitude 758 ft. ambient temperatures up to 104 degrees F.
3. The generator set rating shall be based on emergency standby service.

B. Performance

1. Voltage regulation shall be plus or minus 0.5 percent for any constant load between no load and rated load. Random voltage variation with any steady load from no load to full load shall not exceed plus or minus 0.5 percent.
2. Frequency regulation shall be isochronous from steady state no load to steady state rated load. Random frequency variation with any steady load from no load to full load shall not exceed plus or minus 0.5%.

3. The diesel engine-generator set shall accept a single step load of 100% nameplate kW and power factor, less applicable derating factors, with the engine-generator set at operating temperature.
4. Motor starting capability shall be a minimum of **1227kVA**. The generator set shall be capable of recovering to a minimum of 90% of rated no load voltage following the application of the specified kVA load at near zero power factor applied to the generator set. Maximum voltage dip on application of this load, considering both alternator performance and engine speed changes shall not exceed 25%**.**
5. The alternator shall produce a clean AC voltage waveform, with not more than 5% total harmonic distortion at full linear load, when measured from line to neutral, and with not more than 3% in any single harmonic, and no 3rd order harmonics or their multiples. Telephone influence factor shall be less than 40.
6. The generator set shall be certified by the engine manufacturer to be suitable for use at the installed location and rating, and shall meet all applicable exhaust emission requirements at the time of commissioning.

C. Construction

1. The engine-generator set shall be mounted on a heavy-duty steel base to maintain alignment between components. The base shall incorporate a battery tray with hold-down clamps within the rails.
2. All switches, lamps, and meters in the control system shall be oil-tight and dust-tight. All active control components shall be installed within a UL/NEMA 3R enclosure. There shall be no exposed points in the control (with the door open) that operate in excess of 50 volts.

D. Connections

1. The generator set load connections shall be composed of silver or tin plated copper bus bars, drilled to accept mechanical or compression terminations of the number and type as shown on the drawings. Sufficient lug space shall be provided for use with cables of the number and size as shown on the drawings.
2. Power connections to auxiliary devices shall be made at the devices, with required protection located at a wall-mounted common distribution panel.
3. Generator set control interfaces to other system components shall be made on a permanently labeled terminal block assembly. Labels describing connection point functions shall be provided.

2.2 ENGINE AND ENGINE EQUIPMENT

A. The engine shall be diesel, 4 cycle, radiator and fan cooled. Minimum displacement shall be **793** cubic inches, with 6 cylinders. The horsepower rating of the engine at its minimum tolerance level shall be sufficient to drive the alternator and all connected accessories. Two cycle engines are not acceptable. Engine accessories and features shall include:

1. An electronic governor system shall provide automatic isochronous frequency regulation. The control system shall actively control the fuel rate and excitation as appropriate to the state of the generator set. Fuel rate shall be regulated as a function of starting,

accelerating to start disconnect speed, accelerating to rated speed. The governing system shall include a programmable warm up at idle and cooldown at idle function. While operating in idle state, the control system shall disable the alternator excitation system.

2. Skid-mounted radiator and cooling system rated for full load operation in 122 degrees F (50 degrees C) ambient as measured at the alternator air inlet. Radiator fan shall be suitable for use in a system with 0.5 in H2O restriction. Radiator shall be sized based on a core temperature that is 20F higher than the rated operation temperature, or prototype tested to verify cooling performance of the engine/radiator/fan operation in a controlled environment. Radiator shall be provided with a duct adapter flange. The equipment manufacturer shall fill the cooling system with a 50/50-ethylene glycol/water mixture prior to shipping. Rotating parts shall be guarded against accidental contact.
3. Electric starter capable of three complete cranking cycles without overheat.
4. Positive displacement, mechanical, full pressure, lubricating oil pump.
5. Full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil level indicator.
6. An engine driven, mechanical, positive displacement fuel pump. Fuel filter with replaceable spin-on canister element. Fuel cooler, suitable for operation of the generator set at full rated load in the ambient temperature specified shall be provided if required for operation due to the design of the engine and the installation.
7. Replaceable dry element air cleaner with restriction indicator.
8. Flexible supply and return fuel lines.
9. Engine mounted battery charging alternator, 35-ampere minimum, and solid-state voltage regulator.
10. Coolant heater

    a. Engine mounted, thermostatically controlled, coolant heater. Heater voltage shall be as shown on the project drawings. The coolant heater shall be UL499 listed and labeled.
    b. The coolant heater shall be installed on the engine with silicone hose connections. Steel tubing shall be used for connections into the engine coolant system wherever the length of pipe run exceeds 12 inches. The coolant heater installation shall be specifically designed to provide proper venting of the system. The coolant heaters shall provisions to isolate the heater for replacement of the heater element without draining the coolant from the generator set. The quick disconnect/automatic sealing couplers shall allow the heater element to be replaced without draining the engine cooling system or significant coolant loss.
    c. The coolant heater shall be provided with a DC thermostat, installed at the engine thermostat housing. An AC power connection box shall be provided for a single AC power connection to the coolant heater system. Provide a circuit for the coolant heater sized in accordance with NEC requirements (circuit breaker, wire and conduit), and fed from the nearest standby emergency panelboard. Route circuit from panelboard to heater underground, buried a minimum of 42” below finished grade.
    d. The coolant heater(s) shall be sized as recommended by the engine manufacturer to warm the engine to a minimum of 104F (40C) in a 40F (4C) ambient, in compliance with NFPA110 requirements, or the temperature required for starting and load pickup requirements of this specification.

11. Provide vibration isolators, spring/pad type, quantity as recommended by the generator set manufacturer. Isolators shall include seismic restraints if required by site location.
12. Starting and Control Batteries shall be calcium/lead antimony type, 24 volt DC, sized as recommended by the engine manufacturer, complete with battery cables and connectors. The batteries shall be capable of a minimum of three complete 15-second cranking cycles at 40F ambient temperature when fully charged.
13. A UL listed/CSA certified 10 amp voltage regulated battery charger shall be provided for each engine-generator set. The charger may be located in an automatic transfer switch, or may be wall mounted, at the discretion of the installer. Input AC voltage and DC output voltage shall be as required. Chargers shall be equipped with float, taper and equalize charge settings. Operational monitors shall provide visual output along with individual form C contacts rated at 4 amps, 120 VAC, 30VDC for remote indication of:

    a. Loss of AC power - red light
    b. Low battery voltage - red light
    c. High battery voltage - red light
    d. Power ON - green light (no relay contact)

2.3 AC GENERATOR

A. Charger shall include an Analog DC voltmeter and ammeter, 12 hour equalize charge timer, and AC and DC fuses.

B. The AC generator shall be; synchronous, four pole, 2/3 pitch, revolving field, drip-proof construction, single prelubricated sealed bearing, air cooled by a direct drive centrifugal blower fan, and directly connected to the engine with flexible drive disc. All insulation system components shall meet NEMA MG1 temperature limits for Class H insulation system and shall be UL1446 listed. Actual temperature rise measured by resistance method at full load shall not exceed 125 degrees Centigrade.

C. The generator shall be capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage not more than 5 percent above or below rated voltage.

D. A permanent magnet generator (PMG) shall be included to provide a reliable source of excitation power for optimum motor starting and short circuit performance. The PMG and controls shall be capable of sustaining and regulating current supplied to a single phase or three phase fault at approximately 300% of rated current for not more than 10 seconds.

E. The sub-transient reactance of the alternator shall not exceed 15 percent, based on the standby rating of the generator set.

2.4 GENERATOR SET CONTROL

A. The generator set shall be provided with a microprocessor-based control system that is designed to provide automatic starting, monitoring, and control functions for the generator set.

The control system shall also be designed to allow local monitoring and control of the generator set, and remote monitoring and control as described in this specification.

B. The control shall be mounted on the generator set, or may be mounted in a free-standing panel next to the generator set if adequate space and accessibility is available. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered.

C. The generator set mounted control shall include the following features and functions:

1. Control Switches

a. Mode Select Switch. The mode select switch shall initiate the following control modes. When in the RUN or MANUAL position the generator set shall start, and accelerate to rated speed and voltage as directed by the operator. A separate push-button to initiate starting is acceptable. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.
b. EMERGENCY STOP switch. Switch shall be Red "mushroom-head" push-button. Depressing the emergency stop switch shall cause the generator set to immediately shut down, and be locked out from automatic restarting.
c. RESET switch. The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.
d. PANEL LAMP switch. Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.

2. Generator Set AC Output Metering. The generator set shall be provided with a metering set including the following features and functions:

a. Digital metering set, 1% accuracy, to indicate generator RMS voltage and current, frequency, output current, output KW, KW-hours, and power factor. Generator output voltage shall be available in line-to-line and line-to-neutral voltages, and shall display all three-phase voltages (line to neutral or line to line) simultaneously.
b. Analog voltmeter, ammeter, frequency meter, power factor meter, and kilowatt (KW) meter. Voltmeter and ammeter shall display all three phases. Meter scales shall be color coded in the following fashion: green shall indicate normal operating condition, amber shall indicate operation in ranges that indicate potential failure, and red shall indicate failure impending. Metering accuracy shall be within 1% at rated output. Only digital metering shall be required.
c. The control system shall monitor the total load on the generator set, and maintain data logs of total operating hours at specific load levels ranging from 0 to 110% of rated load, in 10% increments. The control shall display hours of operation at less than 30% load and total hours of operation at more than 90% of rated load.
d. The control system shall log total number of operating hours, total kWH, and total control on hours, as well as total values since reset.

3. Generator Set Alarm and Status Display.

a. The generator set control shall include LED alarm and status indication lamps. The lamps shall be high-intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions. Functions indicated by the lamps shall include:

1) The control shall include five configurable alarm-indicating lamps. The lamps shall be field adjustable for any status, warning, or shutdown function monitored by the genset. They shall also be configurable for color, and control action (status, warning, or shutdown).
2) The control shall include green lamps to indicate that the generator set is running at rated frequency and voltage, and that a remote start signal has been received at the generator set. The running signal shall be based on actual sensed voltage and frequency on the output terminals of the generator set.
3) The control shall include a flashing red lamp to indicate that the control is not in automatic state, and red common shutdown lamp.
4) The control shall include an amber common warning indication lamp.

b. The generator set control shall indicate the existence of the warning and shutdown conditions on the control panel. All conditions indicated below for warning shall be field-configurable for shutdown. Conditions required to be annunciated shall include:

1) low oil pressure (warning)
2) low oil pressure (shutdown)
3) oil pressure sender failure (warning)
4) low coolant temperature (warning)
5) high coolant temperature (warning)
6) high coolant temperature (shutdown)
7) high oil temperature (warning)
8) engine temperature sender failure (warning)
9) low coolant level (warning)
10) fail to crank (shutdown)
11) fail to start/overcrank (shutdown)
12) overspeed (shutdown)
13) low DC voltage (warning)
14) high DC voltage (warning)
15) weak battery (warning)
16) low fuel-daytank (warning)
17) high AC voltage (shutdown)
18) low AC voltage (shutdown)
19) under frequency (shutdown)
20) over current (warning)
21) over current (shutdown)
22) short circuit (shutdown)
23) over load (warning)

24) emergency stop (shutdown)
25) (4) configurable conditions

c. Provisions shall be made for indication of four customer-specified alarm or shutdown conditions. Labeling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above-specified conditions. The non-automatic indicating lamp shall be red, and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.

D. Engine Status Monitoring

1. The following information shall be available from a digital status panel on the generator set control:

a. engine oil pressure (psi or kPA)
b. engine coolant temperature (degrees F or C)
c. engine oil temperature (degrees F or C)
d. engine speed (rpm)
e. number of hours of operation (hours)
f. number of start attempts
g. battery voltage (DC volts)

2. The control system shall also incorporate a data logging and display provision to allow logging of the last 10 warning or shutdown indications on the generator set, as well as total time of operation at various loads, as a percent of the standby rating of the generator set.

E. Engine Control Functions

1. The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and # of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15-second rest period between cranking periods.
2. The control system shall include an idle mode control, which allows the engine to run in idle mode in the RUN position only. In this mode, the alternator excitation system shall be disabled.
3. The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting.
4. The control system shall include time delay start (adjustable 0-300 seconds) and time delay stop (adjustable 0-600 seconds) functions.
5. The control system shall include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which is capable of discriminating between failed sender or wiring components, and an actual failure conditions.

F. Alternator Control Functions:

1. The generator set shall include a full wave rectified automatic digital voltage regulation system that is matched and prototype tested by the engine manufacturer with the governing system provided. It shall be immune from misoperation due to load-induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulation system shall be equipped with three-phase line to neutral RMS sensing and shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below an adjustable frequency threshold. Torque matching characteristic shall be adjustable for roll-off frequency and rate, and be capable of being curve-matched to the engine torque curve with adjustments in the field. The voltage regulator shall include adjustments for gain, damping, and frequency roll-off. Adjustments shall be broad range, and made via digital raise-lower switches, with an alphanumeric LED readout to indicate setting level. Rotary potentiometers for system adjustments are not acceptable.
2. Controls shall be provided to monitor the output current of the generator set and initiate an alarm (over current warning) when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (over current shutdown). The protective functions provided shall be in compliance to the requirements of NFPA70 article 445.
3. Controls shall be provided to individually monitor all three phases of the output current for short circuit conditions. The control/protection system shall monitor the current level and voltage. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (short circuit shutdown). The protective functions provided shall be in compliance to the requirements of NFPA70 article 445.
4. Controls shall be provided to monitor the KW load on the generator set, and initiate an alarm condition (over load) when total load on the generator set exceeds the generator set rating for in excess of 5 seconds. Controls shall include a load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.
5. An AC over/under voltage monitoring system that responds only to true RMS voltage conditions shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.

G. Other Control Functions

1. The generator set shall be provided with a network communication module to allow Modbus RTU or Native BACNet communications with the generator set control by remote devices. The control shall communicate all engine and alternator data, and allow starting and stopping of the generator set via the network in both test and emergency modes.

2. A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is less than 25VDC or more than 32 VDC. During engine cranking (starter engaged), the low voltage limit shall be disabled, and DC voltage shall be monitored as load is applied to the battery, to detect impending battery failure or deteriorated battery condition.

H. Control Interfaces for Remote Monitoring:

1. The control system shall provide four programmable output relays. These relay outputs shall be configurable for any alarm, shutdown, or status condition monitored by the control. The relays shall be configured to indicate: (1) generator set operating at rated voltage and frequency, (2) common warning, (3) common shutdown, (4) load shed command.
2. A fused 10 amp switched 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit whenever the generator set is running.
3. A fused 10 amp 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit at all times from the engine starting/control batteries.
4. **The control shall be provided with a Modbus RTU or Native BACNet communication network interface as described elsewhere in this specification and shown on the drawings. Coordinate exact requirements with BMS integrator.**

2.5 OTHER EQUIPMENT TO BE PROVIDED WITH THE GENERATOR SET

A. Provide and install a 20-light LED type remote alarm annunciator with horn, flush mounted in wall at location shown on plans. The remote annunciator shall provide all the audible and visual alarms called for by NFPA Standard 110 for level 1 systems for the local generator control panel. Spare lamps shall be provided to allow future addition of other alarm and status functions to the annunciator. Provisions for labeling of the annunciator in a fashion consistent with the specified functions shall be provided. Alarm silence and lamp test switch(es) shall be provided. LED lamps shall be replaceable, and indicating lamp color shall be capable of changes needed for specific application requirements. Alarm horn shall be switchable for all annunciation points. Alarm horn (when switched on) shall sound for first fault, and all subsequent faults, regardless of whether first fault has been cleared, in compliance with NFPA110 3-5.6.2. The interconnecting wiring between the annunciator and other system components shall be monitored and failure of the interconnection between components shall be displayed on the annunciator panel.

B. The annunciator shall include the following alarm labels, audible annunciation features, and lamp colors:

Condition	Lamp Color	Audible Alarm
Normal Power (to Loads)	Green	No
Genset Supplying Load	Amber	No
Genset Running	Green	No
Not in Auto	Red (Flashing)	Yes
High Battery Voltage	Red	Yes

Low Battery Voltage	Red	Yes
Charger AC Failure	Red	Yes
Fail to Start	Red	Yes
Low Engine Temperature	Amber	Yes
Pre-High Engine Temperature	Amber	Yes
High Engine Temperature	Red	Yes
Pre-Low Oil Pressure	Amber	Yes
Low Oil Pressure	Red	Yes
Overspeed	Red	Yes
Low Coolant Level	Amber	Yes
Low Fuel Level	Amber	Yes
Network OK	Green	Yes
(4) Spares	Configurable	Configurable

Low battery voltage lamp shall also be lighted for low cranking voltage or weak battery alarm.

C. The generator set shall be provided with a unit mounted main line circuit breaker, sized to carry the rated output current of the generator set. The circuit breaker shall incorporate electronic trip that operates to protect the alternator under all overcurrent conditions and selectively coordinates with emergency electrical distribution system. The supplier shall submit time overcurrent characteristic curves and thermal damage curve for the alternator, demonstrating the effectiveness of the protection provided.

D. Outdoor Weather-Protective Enclosure

1. The generator set shall be provided with an outdoor enclosure, with the entire package listed under UL2200. The package shall comply with the requirements of the National Electrical Code for all wiring materials and component spacing. The total assembly of generator set, enclosure, and sub-base fuel tank shall be designed to be lifted into place using spreader bars. Housing shall provide ample airflow for generator set operation at rated load in an ambient temperature of 100F. The housing shall have hinged access doors as required to maintain easy access for all operating and service functions. All doors shall be lockable, and include retainers to hold the door open during service. Enclosure roof shall be cambered to prevent rainwater accumulation. Openings shall be screened to limit access of rodents into the enclosure. All electrical power and control interconnections shall be made within the perimeter of the enclosure.

2. The enclosure shall provide sound attenuation so generator set has a maximum of 79dB at 20 ft. from the enclosure at rated output.

3. All sheet metal shall be primed for corrosion protection and finish painted with the manufacturers standard color using a two step electrocoating paint process, or equal meeting the performance requirements specified below. All surfaces of all metal parts shall be primed and painted. The painting process shall result in a coating that meets the following requirements:

a. Primer thickness, 0.5-2.0 mils. Top coat thickness, 0.8-1.2 mils.

b. Gloss, per ASTM D523-89, 80% plus or minus 5%. Gloss retention after one year shall exceed 50%.
c. Crosshatch adhesion, per ASTM D3359-93, 4B-5B.
d. Impact resistance, per ASTM D2794-93, 120-160 inch-pounds.
e. Salt Spray, per ASTM B117-90, 1000+ hours.
f. Humidity, per ASTM D2247-92, 1000+ hours.
g. Water Soak, per ASTM D2247-92, 1000+ hours.

4. Painting of hoses, clamps, wiring harnesses, and other non-metallic service parts shall not be acceptable. Fasteners used shall be corrosion resistant, and designed to minimize marring of the painted surface when removed for normal installation or service work.
5. Enclosure shall be constructed of minimum 12 gauge steel for framework and 14 gauge steel for panels. All hardware and hinges shall be stainless steel.
6. The enclosure shall include the following maintenance provisions:

a. Flexible coolant and lubricating oil drain lines, that extend to the exterior of the enclosure, with internal drain valves
b. External radiator fill provision.

E. Provide a sub-base fuel tank for the generator set, sized to allow for full load operation of the generator set for **24 hours**. The sub-base fuel tank shall be UL142 listed and labeled. Installation shall be in compliance to NFPA37. The fuel tank shall be a double-walled, steel construction and include the following features:

1. Emergency tank and basin vents.
2. Mechanical level gauge.
3. Fuel supply and return lines, connected to generator set with flexible fuel lines as recommended by the engine manufacturer and in compliance to UL2200 and NFPA 37 requirements.
4. Leak detection provisions, wired to the generator set control for local and remote alarm indication.
5. High and low level float switches to indicate fuel level. Wire switches to generator control for local and remote indication of fuel level
6. Basin drain.
7. Integral lifting provisions.

3. OPERATION

3.1 SEQUENCE OF OPERATION

A. Generator set shall start on receipt of a start signal from automatic transfer switches. The start signal shall be via hardwired connection to the generator set control.

B. The generator set shall complete a time delay start period as programmed into the control.

C. The generator set control shall initiate the starting sequence for the generator set. The starting sequence shall include the following functions:

D. The control system shall verify that the engine is rotating when the starter is signaled to operate. If the engine does not rotate after two attempts, the control system shall shut down and lock out the generator set, and indicate “fail to crank” shutdown.

E. The engine shall fire and accelerate as quickly as practical to start disconnect speed. If the engine does not start, it shall complete a cycle cranking process as described elsewhere in this specification. If the engine has not started by the completion of the cycle cranking sequence, it shall be shut down and locked out, and the control system shall indicate “fail to start”.

F. The engine shall accelerate to rated speed and the alternator to rated voltage. Excitation shall be disabled until the engine has exceeded programmed idle speed, and regulated to prevent over voltage conditions and oscillation as the engine accelerates and the alternator builds to rated voltage.

G. On reaching rated speed and voltage, the generator set shall operate as dictated by the control system in isochronous state.

H. When all start signals have been removed from the generator set, it shall complete a time delay stop sequence. The duration of the time delay stop period shall be adjustable by the operator.

I. On completion of the time delay stop period, the generator set control shall switch off the excitation system and shall shut down.

J. Any start signal received after the time stop sequence has begun shall immediately terminate the stopping sequence and return the generator set to isochronous operation.

4. OTHER REQUIREMENTS

4.1 SUBMITTALS

A. Within 10 days after award of contract, provide six sets of the following information for review:

1. Manufacturer’s product literature and performance data, sufficient to verify compliance to specification requirements.
2. A paragraph by paragraph specification compliance statement, describing the differences between the specified and the proposed equipment.
3. Manufacturer's certification of prototype testing.
4. Manufacturer's published warranty documents.
5. Shop drawings showing plan and elevation views with certified overall dimensions, as well as wiring interconnection details.
6. Interconnection wiring diagrams showing all external connections required; with field wiring terminals marked in a consistent point-to-point manner.
7. Manufacturer's installation instructions.

4.2 FACTORY TESTING

A. The generator set manufacturer shall perform a complete operational test on the generator set prior to shipping from the factory. A certified test report shall be provided. Equipment supplied shall be fully tested at the factory for function and performance.

B. Factory testing may be witnessed by the owner and consulting engineer. Costs for travel expenses will be the responsibility of the owner and consulting engineer. Supplier is responsible to provide two weeks notice for testing.

C. Generator set factory tests on the equipment shall be performed at rated load and rated power factor. Generator sets that have not been factory tested at rated power factor will not be acceptable. Tests shall include: run at full load, maximum power, voltage regulation, transient and steady-state governing, single step load pickup, and function of safety shutdowns.

4.3 INSTALLATION

A. Equipment shall be installed by the contractor in accordance with final submittals and contract documents. Installation shall comply with applicable state and local codes as required by the authority having jurisdiction. Install equipment in accordance with manufacturer's instructions and instructions included in the listing or labeling of UL listed products.

B. Installation of equipment shall include furnishing and installing all interconnecting wiring between all major equipment provided for the on-site power system. The contractor shall also perform interconnecting wiring between equipment sections (when required), under the supervision of the equipment supplier.

C. Equipment shall be installed on concrete housekeeping pads. Equipment shall be permanently fastened to the pad in accordance with manufacturer’s instructions and seismic requirements of the site.

D. Equipment shall be initially started and operated by representatives of the manufacturer.

E. All equipment shall be physically inspected for damage. Scratches and other installation damage shall be repaired prior to final system testing. Equipment shall be thoroughly cleaned to remove all dirt and construction debris prior to initial operation and final testing of the system.

4.4 ON-SITE ACCEPTANCE TEST

A. The complete installation shall be tested for compliance with the specification following completion of all site work. Testing shall be conducted by representatives of the manufacturer, with required fuel supplied by Contractor. The Engineer shall be notified in advance and shall have the option to witness the tests.

B. Installation acceptance tests to be conducted on-site shall include a "cold start" test, a two hour full load test, and a one step rated load pickup test in accordance with NFPA 110. Provide a

resistive load bank and make connections for full load test, if necessary. Additionally, a 24 hour run-time test shall be performed at standby rated load. Provide load bank connection for 24 hour test at rated load.

C. Perform a power failure test on the entire installed system. This test shall be conducted by opening the power supply from the utility service, and observing proper operation of the system for at least 2 hours. Coordinate timing and obtain approval for start of test with site personnel.

4.5 TRAINING

A. The equipment supplier shall provide training for the facility operating personnel covering operation and maintenance of the equipment provided. The training program shall be not less than 4 hours in duration and the class size shall be limited to 5 persons. Training date shall be coordinated with the facility owner.

4.6 SERVICE AND SUPPORT

A. The manufacturer of the generator set shall maintain service parts inventory at a central location which is accessible to the service location 24 hours per day, 365 days per year.

B. The generator set shall be serviced by a local service organization that is trained and factory certified in generator set service. The supplier shall maintain an inventory of critical replacement parts at the local service organization, and in service vehicles. The service organization shall be on call 24 hours per day, 365 days per year.

C. The manufacturer shall maintain model and serial number records of each generator set provided for at least 20 years.

4.7 WARRANTY

A. The generator set and associated equipment shall be warranted for a period of not less than 5 years from the date of commissioning against defects in materials and workmanship.

B. The warranty shall be comprehensive. No deductibles shall be allowed for travel time, service hours, repair parts cost, etc.

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(INCLUDED AS PART OF ADD ALTERNATE #2)

SECTION 26 36 23 – AUTOMATIC TRANSFER SWITCH

PART 1 - GENERAL

1.1 SCOPE

A. Furnish and install automatic **open transition transfer & bypass-isolation switch** (ATS/BPS) system(s) with number of poles, amperage, voltage, withstand and close-on ratings as shown on the plans. Each automatic transfer shall consist of an inherently double throw power transfer switch mechanism and a microprocessor controller to provide automatic operation. All automatic transfer & bypass-isolation switches and controllers shall be the products of the same manufacturer.

B. The ATS/BPS shall transfer the load in open transition (break-before-make) mode. Switch shall be provided with all necessary programming, accessories, adjustable settings, and source monitoring required for open transition.

C. The ATS/BPS shall not require rear access. Access for installation and maintenance shall be from front only. As required, provide bottom conduit entry wireway/pullbox on the side of the ATS/BPS to allow for entry of conduit from below the slab. Wireway/pullbox shall be provided by and manufactured by the ATS/BPS manufacturer.

1.2 CODES AND STANDARDS

A. The automatic transfer switches and controls shall conform to the requirements of:

1. UL 1008 - Standard for Transfer Switch Equipment
2. CSA certified to CSA 22.2 No 178 – 1978 Automatic Transfer Switches
3. IEC 60947-6-1 Low-voltage Switchgear and Controlgear; Multifunction equipment; Automatic Transfer Switching Equipment
4. NFPA 70 - National Electrical Code
5. NFPA 99 - Essential Electrical Systems for Health Care Facilities
6. NFPA 110 - Emergency and Standby Power Systems
7. IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
8. NEMA Standard ICS10-1993 (formerly ICS2-447) - AC Automatic Transfer Switches
9. International Standards Organization ISO 9001:2008
10. UL 508 Industrial Control Equipment

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's data and installation instructions for electrical power transfer switches.

B. Shop Drawings: Submit ½"=1'-0" scale layout drawings of electrical generator and transfer switches showing accurately scaled equipment locations, housekeeping pad size, location and spatial relationships to associated electrical equipment in proximity.

A. Wiring Diagrams: Submit wiring diagrams for electrical transfer switches, and associated control devices showing connections to prime and alternate power sources, electrical load, and equipment components. Differentiate between portions of wiring that are manufacturer-installed and portions that are field-installed.

1.4 ACCEPTABLE MANUFACTURERS

A. Automatic open transition transfer & bypass-isolation switches shall be ASCO 7000 Series or approved equivalent. Equivalent equipment by Cummins or Russ Electric is acceptable. Any alternate shall be submitted for approval to the consulting engineer at least 10 days prior to bid. Alternate bids must list any deviations from this specification.

PART 2. PRODUCTS

2.1 MECHANICALLY HELD TRANSFER SWITCH

A. The transfer switch shall be electrically operated and mechanically held. The electrical operator shall be a momentarily energized, single-solenoid mechanism. Main operators which include overcurrent disconnect devices, linear motors or gears shall not be acceptable. The switch shall be mechanically interlocked to ensure only two possible positions, normal or emergency.

B. All transfer switch sizes shall use only one type of main operator for ease of maintenance and commonality of parts.

C. The switch shall be positively locked and unaffected by momentary outages, so that contact pressure is maintained at a constant value and contact temperature rise is minimized for maximum reliability and operating life.

D. All main contacts shall be silver composition. Switches rated 800 amperes and above shall have segmented, blow-on construction for high withstand and close-on capability and be protected by separate arcing contacts.

E. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. Switches rated 800 amps and higher shall have front removable and replaceable contacts. All stationary and moveable contacts shall be replaceable without removing power conductors and/or bus bars.

F. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof, which are not intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.

G. Where neutral conductors must be switched as shown on the plans, the AS shall be provided with fully rated overlapping neutral transfer contacts. The neutrals of the normal and emergency power sources shall be connected together only during the transfer and retransfer operation and remain connected together until power source contacts close on the source to which the transfer is being made. The overlapping neutral contacts shall not overlap for a period greater than 100 milliseconds. Neutral switching contacts which do not overlap are not acceptable.

H. Where neutral conductors are to be solidly connected as shown on the plans, a neutral conductor plate with fully rated AL-CU pressure connectors shall be provided.

2.2 BYPASS-ISOLATION SWITCH

A. A two-way bypass-isolation switch shall provide manual bypass of the load to either source and permit isolation of the automatic transfer switch from all source and load power conductors. All main contacts shall be manually driven.

B. Power interconnections shall be silver-plated copper bus bar. The only field installed power connections shall be at the service and load terminals of the bypass-isolation switch. All control interwiring shall be provided with disconnect plugs.

C. Separate bypass and isolation handles shall be utilized to provide clear distinction between the functions. Handles shall be permanently affixed and operable without opening the enclosure door. Designs requiring insertion of loose operating handles or opening of the enclosure door to operate are not acceptable.

D. Bypass to the load-carrying source shall be accomplished with no interruption of power to the load (make before break contacts). Designs which disconnect the load when bypassing are not acceptable. The bypass handle shall have three operating modes: "Bypass to Normal," "Automatic," and "Bypass to Emergency." The operating speed of the bypass contacts shall be the same as the associated transfer switch and shall be independent of the speed at which the manual handle is operated. In the "Automatic" mode, the bypass contacts shall be out of the power circuit so that they will not be subjected to fault currents to which the system may be subjected.

E. The isolation handle shall provide three operating modes: "Closed," "Test," and "Open." The "Test" mode shall permit testing of the entire emergency power system, including the automatic transfer switches with no interruption of power to the load. The "Open" mode shall completely isolate the automatic transfer switch from all source and load power conductors. When in the "Open" mode, it shall be possible to completely withdraw the automatic transfer switch for inspection or maintenance to conform to code requirements without removal of power conductors or the use of any tools.

F. When the isolation switch is in the "Test" or "Open" mode, the bypass switch shall function as a manual transfer switch.

G. Designs requiring operation of key interlocks for bypass isolation or ATSs which cannot be completely withdrawn when isolated are not acceptable.

2.3 MICROPROCESSOR CONTROLLER

A. The controller's sensing and logic shall be provided by a single built-in microprocessor for maximum reliability, minimum maintenance, and the ability to communicate serially through an optional serial communication module.

B. A single controller shall provide twelve selectable nominal voltages for maximum application flexibility and minimal spare part requirements. Voltage sensing shall be true RMS type and shall be accurate to plus or minus 1% of nominal voltage. Frequency sensing shall be accurate to plus or minus 0.2%. The panel shall be capable of operating over a temperature range of -20 to +60 degrees C and storage from -55 to +85 degrees C.

C. The controller shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the controller to be disconnected from the transfer switch for routine maintenance. Sensing and control logic shall be provided on multi-layer printed circuit boards. Interfacing relays shall be industrial grade plug-in type with dust covers. The panel shall be enclosed with a protective cover and be mounted separately from the transfer switch unit for safety and ease of maintenance. The protective cover shall include a built-in pocket for storage of the operator's manuals.

D. All customer connections shall be wired to a common terminal block to simplify field-wiring connections.

E. The controller shall meet or exceed the requirements for Electromagnetic Compatibility (EMC) as follows:

1. EN 55011:1991 Emission standard - Group 1, Class A
2. EN 50082-2:1995 Generic immunity standard, from which:
3. EN 61000-4-2:1995 Electrostatic discharge (ESD) immunity
4. ENV 50140:1993 Radiated Electro-Magnetic field immunity
5. EN 61000-4-4:1995 Electrical fast transient (EFT) immunity
6. EN 61000-4-5:1995 Surge transient immunity
7. EN 61000-4-6:1996 Conducted Radio-Frequency field immunity

2.4 ENCLOSURE

A. The ATS/BPS shall be furnished in a Type 1 enclosure unless otherwise shown on the plans.

B. All standard and optional door-mounted switches and pilot lights shall be 16- mm industrial grade type or equivalent for easy viewing & replacement. Door controls shall be provided on a separate removable plate, which can be supplied loose for open type units.

PART 3. OPERATION

3.1 CONTROLLER DISPLAY AND KEYPAD

A. A four line, 20 character LCD display and keypad shall be an integral part of the controller for viewing all available data and setting desired operational parameters. Operational parameters shall also be available for viewing and limited control through the serial communications input port. The following parameters shall only be adjustable via DIP switches on the controller:

1. Nominal line voltage and frequency
2. Single or three phase sensing
3. Operating parameter protection
4. Transfer operating mode configuration

(**Open transition**, Closed transition or Delayed transition)

All instructions and controller settings shall be easily accessible, readable and accomplished without the use of codes, calculations, or instruction manuals.

3.2 VOLTAGE, FREQUENCY AND PHASE ROTATION SENSING

A. Voltage and frequency on both the normal and emergency sources (as noted below) shall be continuously monitored, with the following pickup, dropout and trip setting capabilities (values shown as % of nominal unless otherwise specified):

Parameter	Sources	Dropout / Trip	Pickup / Reset
Undervoltage	N&E,3PH	70 to 98%	85 to 100%
Overvoltage	N&E,3PH	102 to 115%	2% below trip
Underfrequency	N&E	85 to 98%	90 to 100%
Overfrequency	N&E	102 to 110%	2% below trip
Voltage unbalance	N&E	5 to 20%	1% below dropout

B. Repetitive accuracy of all settings shall be within ± 0.5% over an operating temperature range of -20 degrees C to 60 degrees C.

C. Voltage and frequency settings shall be field adjustable in 1% increments either locally with the display and keypad or remotely via serial communications port access.

D. The controller shall be capable (when activated by the keypad or through the serial port) of sensing the phase rotation of both the normal and emergency sources. The source shall be considered unacceptable if the phase rotation is not the preferred rotation selected (ABC or CBA).

E. Source status screens shall be provided for both normal & emergency to provide digital readout of voltage on all 3 phases, frequency, and phase rotation.

F. The controller shall include a user selectable algorithm to prevent repeated transfer cycling to a source on an installation which experiences primary side, single phase failures on a Grounded Wye – Grounded Wye transformer which regenerates voltage when unloaded. The algorithm shall also inhibit retransfer to the normal (utility) source upon detection of a single phasing condition until a dedicated timer expires, the alternate source fails, or the normal source fails completely and is restored during this time delay period. The time delays associated with this feature shall be adjustable by the user through the controller keypad and LCD.

3.3 TIME DELAYS

A. An adjustable time delay of 0 to 6 seconds shall be provided to override momentary normal source outages and delay all transfer and engine starting signals. Capability shall be provided to extend this time delay to 60 minutes by providing an external 24 VDC power supply.

B. A time delay shall be provided on transfer to emergency, adjustable from 0 to 60 minutes, for controlled timing of transfer of loads to emergency.

C. Two time delay modes (which are independently adjustable) shall be provided on re-transfer to normal. One time delay shall be for actual normal power failures and the other for the test mode function. The time delays shall be adjustable from 0 to 60 minutes. Time delay shall be automatically bypassed if the emergency source fails and the normal source is acceptable.

D. A time delay shall be provided on shut down of engine generator for cool down, adjustable from 0 to 60 minutes.

E. A time delay activated output signal shall also be provided to drive an external relay(s) for selective load disconnect control. The controller shall have the ability to activate an adjustable 0 to 5 minute time delay in any of the following modes:

1. Prior to transfer only.
2. Prior to and after transfer.
3. Normal to emergency only.
4. Emergency to normal only.
5. Normal to emergency and emergency to normal.
6. All transfer conditions or only when both sources are available.

F. The controller shall also include the following built-in time delays for optional Closed Transition and Delayed Transition operation:

1. 1 to 5 minute time delay on failure to synchronize normal and emergency sources prior to closed transition transfer.

2. 0.1 to 9.99 second time delay on an extended parallel condition of both power sources during closed transition operation.
3. 0 to 5 minute time delay for the load disconnect position for delayed transition operation.

G. All time delays shall be adjustable in 1 second increments, except the extended parallel time, which shall be adjustable in .01 second increments.

H. All time delays shall be adjustable by using the LCD display and keypad or with a remote device connected to the serial communications port.

3.4 ADDITIONAL FEATURES

A. A three position momentary-type test switch shall be provided for the *test / automatic / reset* modes. The test position will simulate a normal source failure. The reset position shall bypass the time delays on either transfer to emergency or retransfer to normal.

B. A SPDT contact, rated 5 amps at 30 VDC, shall be provided for a low-voltage engine start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output, and run for the duration of the cool down setting, regardless of whether the normal source restores before the load is transferred.

C. Auxiliary contacts, rated 10 amps, 250 VAC shall be provided consisting of one contact, closed when the ATS is connected to the normal source and one contact closed, when the ATS is connected to the emergency source.

D. LED indicating lights (16 mm industrial grade, type 12) shall be provided; one to indicate when the ATS is connected to the normal source (green) and one to indicate when the ATS is connected to the emergency source (red).

E. LED indicating lights (16 mm industrial grade, type 12) shall be provided and energized by controller outputs. The lights shall provide true source availability of the normal and emergency sources, as determined by the voltage sensing trip and reset settings for each source.

THE FOLLOWING FEATURES SHALL BE BUILT-IN TO THE CONTROLLER, BUT CAPABLE OF BEING ACTIVATED THROUGH KEYPAD PROGRAMMING OR THE SERIAL PORT ONLY WHEN REQUIRED BY THE USER:

F. Provide the ability to select “commit/no commit to transfer” to determine whether the load should be transferred to the emergency generator if the normal source restores before the generator is ready to accept the load.

G. An Inphase monitor shall be provided in the controller. The monitor shall control transfer so that motor load inrush currents do not exceed normal starting currents, and shall not require external control of power sources. The inphase monitor shall be specifically designed for and be the product of the ATS manufacturer. The inphase monitor shall be equal to ASCO Feature 27.

H. The controller shall be capable of accepting a normally open contact that will allow the transfer switch to function in a non-automatic mode using an external control device.

I. Engine Exerciser - The controller shall provide an internal engine exerciser. The engine exerciser shall allow the user to program up to seven different exercise routines. For each routine, the user shall be able to:

1. Enable or disable the routine.
2. Enable or disable transfer of the load during routine.
3. Set the start time, .
   - time of day
   - day of week
   - week of month (1st, 2nd, 3rd, 4th, alternate or every)
4. Set the duration of the run.
5. At the end of the specified duration the switch shall transfer the load back to normal and run the generator for the specified cool down period. A 10-year life battery that supplies power to the real time clock in the event of a power loss will maintain all time and date information.

THE FOLLOWING FEATURE SHALL BE BUILT - INTO THE CONTROLLER, BUT CAPABLE OF BEING ACTIVATED THROUGH KEYPAD PROGRAMMING OR THE COMMUNICATIONS INTERFACE PORT.

Note: The transfer switch will operate in a non-automatic mode with this feature activated.

J. Terminals shall be provided for a remote contact which opens to signal the ATS to transfer to emergency and for remote contacts which open to inhibit transfer to emergency and/or retransfer to normal. Both of these inhibit signals can be activated through the keypad or serial port.

K. System Status - The controller LCD display shall include a “System Status” screen which shall be readily accessible from any point in the menu by depressing the “ESC” key a maximum of two times. This screen shall display a clear description of the active operating sequence and switch position. For example,

NORMAL FAILED
LOAD ON NORMAL
TD Normal to Emerg
2min15s

Controllers that require multiple screens to determine system status or display “coded” system status messages, which must be explained by references in the operator’s manual, are not permissible.

L. Self Diagnostics - The controller shall contain a diagnostic screen for the purpose of detecting system errors. This screen shall provide information on the status input signals to the controller which may be preventing load transfer commands from being completed.

M. Data Logging – The controller shall have the ability to log data and to maintain the last 99 events, even in the event of total power loss. The following events shall be time and date stamped and maintained in a non- volatile memory:

1. Event Logging

   a. Data and time and reason for transfer normal to emergency.
   b. Data and time and reason for transfer emergency to normal.
   c. Data and time and reason for engine start.
   d. Data and time engine stopped.
   e. Data and time emergency source available.
   f. Data and time emergency source not available.

2. Statistical Data

   a. Total number of transfers.
   b. Total number of transfers due to source failure.
   c. Total number of days controller is energized.
   d. Total number of hours both normal and emergency sources are available.

N. Communications Module – Shall provide remote interface module to support monitoring of vendor's transfer switch, controller and optional power meter. Module shall provide status, analog parameters, event logs, equipment settings & configurations over embedded webpage and open protocol. Features shall include:

1. Email notifications and SNMP traps of selectable events and alarms may be sent to a mobile device or PC.
2. Modbus TCP/IP, SNMP, HTTP, SMTP open protocols shall be simultaneously supported.
3. Web app interface requiring user credentials to monitor and control the transfer switch supporting modern smart phones, tablets and PC browsers. User will be able to view the dynamic one-line; ATS controls status, alarms, metering, event logging as well as settings.
4. Secure access shall be provided by requiring credentials for a minimum of 3 user privilege levels to the web app, monitor (view only), control (view and control) and administrator (view, control and change settings). 128-Bit AES encryption standard shall be supported for all means of connectivity.
5. Shall allow for the initiating of transfers, retransfers, bypassing of active timers and the activating/deactivating of engine start signal shall be available over the embedded webpage and to the transfer switch vendor's monitoring equipment.
6. An event log displaying a minimum of ninety-nine (300) events shall be viewable and printable from the embedded webpages and accessible from supported open protocols.

7. Four (4) 100 Mbps Ethernet copper RJ-45 ports, five (2) serial ports, Termination dip-switches and LEDs for diagnostics.
8. DIN rail mountable.

This option shall be equivalent to ASCO accessory 72EE2

O. External DC Power Supply – An optional provision shall be available to connect an external 24 VDC power supply to allow the LCD and the door mounted control indicators to remain functional when both power sources are dead. This option shall be equivalent to ASCO accessory 1G.

P. The ATS shall be provided with a Modbus RTU or Native BACNet communication network interface module for communication of transfer switch alarms/status. Coordinate exact requirements with BMS integrator.

PART 4. ADDITIONAL REQUIREMENTS

4.1 WITHSTAND AND CLOSING RATINGS

A. The ATS/BPS shall be rated to close on and withstand the available RMS symmetrical short circuit current at the ATS/BPS terminals with the type of overcurrent protection shown on the plans.

B. The ATS/BPS shall be UL listed in accordance with UL 1008 and be labeled in accordance with .025 and .050 seconds, time-based ratings, or appropriate short time rating(s) as applicable. ATS/BPSs which are not tested and labeled with.025 and.050 seconds time-based rating(s) or appropriate short time rating(s) and have series, or specific breaker ratings only, are not acceptable.

4.2 TESTS AND CERTIFICATION

A. The complete ATS/BPS shall be factory tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency and time delay settings are in compliance with the specification requirements.

B. The ATS/BPS manufacturer shall be certified to ISO 9001:2008 International Quality Standard and the manufacturer shall have third party certification verifying quality assurance in design/development, production, installation and servicing in accordance with ISO 9001:2008

4.3 SERVICE REPRESENTATION

A. The ATS/BPS manufacturer shall maintain a national service organization of company-employed personnel located throughout the contiguous United States. The service center's personnel must be factory trained and must be on call 24 hours a day, 365 days a year.

B. The manufacturer shall maintain records of each switch, by serial number, for a minimum of 20 years.

4.4 WARRANTY

A. Equipment shall be warranted for a period of not less than 3 years from the date of commissioning against defects in materials and workmanship.

B. The warranty shall be comprehensive. No deductibles shall be allowed for travel time, service hours, repair parts cost, etc.

END OF SECTION 26 36 23

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SECTION 26 41 00 – LIGHTNING PROTECTION SYSTEM

PART 1. GENERAL

1.1 SUMMARY

A. The existing portion of the Nextgen Center of Excellence for Influenza Research building has an existing lightning protection system currently installed. Expand the existing system to fully cover the new construction portion of the building addition. The new portion of the lightning protection system shall fully integrate with and tie into the existing system so as to provide full protection of the building. The design of this system is to be in strict accordance with this section of the specifications and all contract drawings that apply.

B. The lightning protection system shall be designed and installed by a firm actively engaged in the installation of Underwriters Laboratories Inc. (UL) Master Labeled Lightning Protection Systems and shall be so listed by Underwriters Laboratories Inc. The completed system shall comply with the latest editions of Underwriters Laboratories Inc. “Installation Requirements for Lightning Protection Systems, UL96A” and of the National Fire Protection Association’s “NFPA® 780, Standard for the Installation of Lightning Protection Systems”. The system shall be physically inspected by UL and the Master Label® Certificate of Inspection shall be provided to the building owner and made available for viewing on the UL website, https://lps.ul.com.

C. The work covered under this section of the specification consists of furnishing labor, materials and services required for the completion of a functional and unobtrusive lightning protection system approved by the architect, engineer and Underwriters Laboratories Inc.

D. System designs shall be completely integrated with the architectural design of the facility, and shall be reviewed by the Architect/Engineer prior to installation. The lightning protection system installation in shall be fully coordinated with all other trades.

1.2 STANDARDS

A. The completed lightning protection system shall comply with the latest issue of the following standards which form a part of this specification. Where conflict occur between the two standards, the requirements of NFPA®780 shall apply.

1. NFPA® 780, Standard for the Installation of Lightning Protection Systems.
2. UL 96A, Installation Requirements for Lightning Protection Systems.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer’s descriptive and technical literature and catalog cuts.

B. Shop Drawings: Installation shop drawings shall be submitted to the Architect and Engineer for coordination with other trades and approval prior to start of the installation. Shop drawings are to show the extent of the system layout designed specifically for the building(s) or structures included in the contract drawings along with installation details of the products to be used in the installation.

1.4 QUALITY ASSURANCE

A. The installing contractor shall apply for inspection of the completed system by UL field representatives. The system is to be inspected by Underwriters Laboratories Inc, or other ANSI certified testing agency for compliance with NFPA® 780. The system shall be without deviation and the UL field representative will issue a UL Master Label® Certificate of Inspection for Lightning Protection Systems or Letter of Findings at completion of the installation, as indicated in section 3.04 below.

B. Manufacturer: Company specializing in lightning protection equipment with a minimum of five years of documented experience.

C. System Designer: Company specializing in the design of lightning protection systems with a minimum of five years of documented experience.

D. Installer: Authorized installer of system manufacturer with a minimum of five years of documented experience.

PART 2. PRODUCTS

2.1 MATERIALS

A. All materials used in the installation shall be new and shall comply in weight, size and composition as required by UL 96A and NFPA® 780 and shall be labeled or listed by Underwriters Laboratories Inc. for use in lightning protection systems. The system furnished under this specification shall be the standard product of a manufacturer regularly engaged in the production of lightning protection equipment. The manufacturer shall be listed by UL as a manufacturer of lightning protection components.

2.2 ACCEPTABLE MANUFACTURERS

A. Harger Lightning & Grounding.

B. National Lightning Protection Corporation.

C. Robbins Lightning Protection Company.

D. Thompson Lightning Protection, Inc.

E. Preferred Lightning Protection.

2.3 MATERIAL REQUIREMENTS

A. Class I materials shall be used on structures or portions of structures that do not exceed 75 feet in height above grade level. Class II materials shall be used on structures that exceed 75 feet in height above grade.

B. Copper materials shall not be mounted on aluminum, Galvalume®, galvanized steel or zinc surfaces. This includes those materials that have been painted.

C. Aluminum materials shall not come into contact with earth or where rapid deterioration is possible. Aluminum materials shall not come into contact with copper surfaces or where exposed to runoff from copper surfaces. Aluminum materials shall not be attached to surfaces covered with alkaline-based paint, embedded in concrete or masonry, or installed in a location subject to excessive moisture.

2.4 AIR TERMINALS

A. Air terminals shall extend a minimum of ten inches above the object or area they are to protect. Air terminals shall be located at intervals not exceeding 20’-0” along ridges of pitched roofs and along the perimeter of flat or gently sloping roofs (flat or gently sloping roofs include roofs that have a pitch less than 3:12). Flat or gently sloping roofs exceeding 50’-0” in width shall be provided with additional air terminals located at intervals not exceeding 50’. Air terminals shall be located within two feet of the ends of the ridges, roof edges and outside corners of protected areas.

B. Air terminals shall be installed on stacks, flues, mechanical units and other objects not located within a zone of protection. Permanent metal objects on the structure having an exposed metal thickness 3/16” or greater may be substituted for air terminals and shall connected to the lightning protection system as required by the specified standards using main size conductor and bonding plates having a minimum of 3 square inches of surface contact area.

C. Air terminal bases shall be securely fastened to the structure in accordance with the specified standards. Fasteners may include stainless steel screws, bolts, nails, anchors or adhesive. Adhesive shall be compatible with the surface on which it is used. Any protective sheets or pads that may be required by the roofing manufacturer shall be furnished and installed by the roofing contractor.

D. Main conductors shall be sized as Class I or Class II materials in accordance with the specified standards. Conductors shall provide a two way, horizontal or downward path from each strike or air terminal to connections to the lightning protection ground electrode system. Conductors shall be free of excessive splices and no bend of a conductor shall form an included angle of less than 90 degrees nor have a radius of bend less than 8 inches.

E. Conductors shall be securely fastened to the structure on which they are placed at intervals not exceeding 3 feet. Fasteners shall be of the same material or of a material equally resistant to corrosion as that of the conductor. Any protective sheets or pads that may be required by the roofing manufacturer shall be furnished and installed by the roofing contractor.

F. Connector fittings shall be listed for the purpose and of the same material as the conductor or of electrolytically compatible materials.

G. Down conductors shall be sized as Class I or Class II materials in accordance with the specified standards. Class II conductors from a higher portion of a structure shall continue to connections to the lightning protection ground electrode system. Down conductors shall be spaced at intervals averaging not more than 100 feet around the perimeter of the structure. In no case shall a structure have fewer than two down conductors. Down conductors shall be concealed from view. All conductors shall be concealed from view at street level.

H. In case of structural steel frame construction, down conductors may be omitted and roof conductors shall be connected to the structural steel frame at intervals not exceeding 100 feet along the perimeter of the structure.

2.5 ROOF PENETRATIONS

A. Roof penetrations required for down conductors or for connection to structural steel framework shall be made using thru-roof assemblies with solid riser bars or conduits and appropriate roof flashing. Conductors shall not pass directly through the roof. The roofing contractor shall furnish and install the materials required to properly seal all roof penetrations of the lightning protection components and any additional roofing materials or preparations required by the roofing manufacturer for lightning conductor runs to assure compatibility with the warranty for the roof including roof pads that may be required to protect the roof under each of the lightning protection components.

2.6 GROUND ELECTRODES

A. Each down conductor shall terminate at a ground electrode dedicated to the lightning protection system, or to a building or facility ground electrode system that consists of multiple ground electrodes that are interconnected with a ground ring conductor.

B. Ground rod electrodes shall be copper-clad steel, a minimum 5/8” diameter and 10 feet long. The down conductor shall be connected to the ground electrode using a bronze ground rod clamp having a minimum of 1½” contact between the ground rod electrode and the conductor measured parallel to the axis of the ground rod electrode, or by an Ultraweld exothermically welded connection. Ground rod electrodes shall be located a minimum of 2 feet below grade and shall be installed below the frost line where possible (excluding shallow topsoil conditions).

C. Where it is not possible to drive ground rod electrodes because of bedrock or shallow topsoil conditions, ground plate electrodes, radial electrodes, ground ring electrodes, concrete-encased electrodes, or combinations of these may be used in accordance with NFPA® 780.

D. Where the structural steel framework is utilized as down conductors for the system, ground electrodes shall be connected to columns around the perimeter of the structure at intervals averaging not more than 60 feet apart. Columns shall be grounded using either bonding plates having 8 square inches of surface contact area or by Ultraweld® exothermically welded connections.

2.7 COMMON BONDING OF GROUNDED SYSTEMS

A. Common bonding of all grounded systems within the building shall be ensured by interconnecting them to the lightning protection system using main size conductor and fittings.

B. For structures exceeding 60 feet in height, the interconnection of the lightning protection system ground electrodes and other grounded systems shall be in the form of a ground loop conductor.

C. These grounded systems shall include but are not limited to the electrical service, communication, and antenna system grounds as well as all underground metallic piping systems including water, gas, sewer, underground metallic conduits, etc. Interconnection to a gas line shall be made on the customer's side of the meter.

2.8 POTENTIAL EQUALIZATION

A. Grounded metal bodies located within the required bonding distance as determined by the bonding distance formula in NFPA® 780 shall be bonded to the lightning protection system using the required bonding conductors and connections.

PART 3. EXECUTION

3.1 INSTALLATION

A. The installation of the lightning protection system shall be done in a neat and workmanlike manner.

B. The lightning protection system shall be installed by or under the supervision of a UL listed lighting protection installer.

C. The installers shall have completed factory training and be so certified by the manufacturer.

D. Install the lightning protection system in accordance with the approved coordinated shop drawing and the referenced lightning protection system installation standards. Any deviations shall be brought to the immediate attention of the manufacturer so as not to delay certification.

E. Splices and clamps: Install cable with as few joints as possible. Use approved exothermic welded connections for all above grade connections, ungrounded conductor splices and all underground connections between conductors and ground rods. Use approved mechanical compression connections for above grade connections with specific Owner approval only.

F. Systems shall be semi-concealed, with all down-lead conductors and groundings concealed within the building, but with roof conductors and air terminals exposed on roof. Where possible, roof conductors and air terminals shall be installed on inside faces of parapets so that they are not visible from below.

G. Copper downlead conductors shall be used even when aluminum is required on the roof. Downlead cables in conduit shall not be brought directly through the roof. Thru roof assemblies with solid brass or stainless steel rods shall be utilized for this purpose.

H. PVC conduits may be used to conceal conductors, separate conductors from dissimilar metals, etc., in areas where there is no risk of physical damage. In areas where physical damage is probable; rigid metal conduit shall be used. The contractor shall ensure conduit materials meet above ceiling plenum ratings, where installed in that environment.

I. Ground Rods:

1. Install rods by driving and not by drilling or jetting.
2. Drive rods into unexcavated portions of the earth where possible.
3. Where rods must be installed in excavated areas, drive rods into earth after compaction of backfill is completed.
4. Drive to a depth such that the top of the rod will be approximately 18” below final grade or sub-grade.
5. Bond exterior metal bodies on building to the lightning protection system.

J. Corrosion Protection:

1. Use no combination of materials that may form an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture unless moisture is permanently excluded from the junction of such metals. Where unusual conditions exist that would cause deterioration or corrosion of conductors, use conductors with suitable protective coatings. Protect cable at all points where cable leaves concrete by wrapping rubber tape 2” on either side of the plane formed by the finished concrete surface.

3.2 COORDINATION

A. Coordinate the installation of the lightning protection system with other trades.

B. Coordinate all roof penetrations, fasteners and adhesive with the roofing contractor prior to installing any materials on the roof.

3.3 PROJECT DOCUMENTATION

A. Photo document all concealed portions of the lightning protection system as they are being installed. This includes lightning protection system grounding electrodes, connections to structural metal, connections to underground metal piping entering the structure, connections to

electrical and electronic service grounds, ground rings, etc. This documentation should be authenticated by the Owner or his representative.

B. Maintain accurate "as-built" drawings throughout the entire installation of the lightning protection system.

3.4 INSPECTION, CERTIFICATION AND MAINTENANCE

A. At completion of the installation of the lightning protection system, the contractor shall apply for inspection of the system by UL field representatives. The system is to be inspected for compliance with NFPA® 780. Owner's Representative shall receive at least at least 48-hour notification of an any inspection performed by the UL inspector.

B. If the lightning protection system covers an entire independent structure and the system passes inspection, UL will issue a Master Label® Certificate of Inspection for Lightning Protection System. The contractor will submit the certificate for distribution to the premises' Owner. For the certificate to be valid, the contractor must publish the certificate to the UL website, https://lps.ul.com where it may be viewed by consumers, building owners, insurance agencies and other interested parties. The Master Label® Certificate of Inspection is valid for a period of five years. If the building changes structurally or if modifications are made to the system during that period, the certificate is no longer valid.

C. At project closeout, the contractor shall provide the Owner with accurate as-built drawings as well as recommended guidelines for maintenance of the system.

END OF SECTION 26 41 00

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SECTION 26 51 00- LIGHTING

1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections apply to the work of this Section.

B. Division 26 "Basic Materials and Methods" sections apply to the work in this Section.

1.2 DESCRIPTION OF WORK

A. Types of interior and exterior lighting fixtures in this Section include the following:

1. LED

1.3 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in the manufacturer of interior and exterior light fixtures of types and ratings required, whose products have been in satisfactory use in similar service for not less than three years.

B. Installer: Qualified with at least three years of successful installation experience on projects with interior and exterior lighting fixture work similar to that required for this project.

1.4 REFERENCES

A. NEC Compliance: Comply with the NEC as applicable to the installation and construction of lighting fixtures.

B. NEMA Compliance: Comply with applicable requirements of NEMA Standard Pub. Nos. LE-1 and LE-2 pertaining to lighting equipment.

C. ANSI/UL Compliance: Comply with ANSI/UL Standards pertaining to interior and exterior lighting fixtures for hazardous locations.

D. UL Compliance: Provide light fixtures that have been UL listed and labeled.

E. NECA Compliance: Comply with NECA's "Standard of Installation".

1.5 SUBMITTALS

A. Product Data: Submit manufacturer's product data on lighting fixtures.

B. SHOP DRAWINGS

1. Furnish shop drawing portfolios (collated bound sets) containing the following information:

   a. Name of manufacturer
   b. Descriptive cut sheets
   c. Complete photometric information
   d. Coefficient of utilization tables
   e. Fixture voltage
   f. The number, type and wattage of the fixture lamps
   g. Lens types
   h. Fixture options
   i. Fixture mounting details
   j. Fixture door types
   k. Construction of fixture housing and/or door
   l. Fixture ballast manufacturer and type

2. All lighting fixtures required to be used on this project shall be submitted in one single submittal so that all fixtures can be reviewed at one time. Those fixtures not receiving a shop drawing action of "Reviewed" or "Reviewed and Noted" on the first submittal shall be resubmitted for review. A light fixture receiving a shop drawing action of "Resubmit" or "Rejected" after the third review for any reason, shall be furnished as originally specified.
3. The portfolios shall be made from standard manufacturer's specification sheets. Each fixture shall be identified by the letter or number indicated on the fixture schedule. The combining of more than one fixture type of fixture on a single sheet shall not be acceptable.

2. PRODUCTS

2.1 Manufacturer: Manufacturers of lighting fixtures are noted on the drawings by notes and/or by the light fixture schedule.

2.2 Substitutions: If the Contractor proposes to substitute lighting fixtures for those shown on the drawings or specified herein, he shall submit a list of proposed fixtures together with technical data to substantiate that the substitute fixtures are equivalent in all respects to the specified equipment. Proposed substitute fixtures must be submitted to the architect/engineer for review a minimum of ten (10) days prior to the project bid date. Only original documentation will be accepted for review. After review of the proposed substitute fixtures, an addendum or bid bulletin will be issued to include acceptable equipment. The review of substitute equipment in no way relieves the contractor of the responsibility to provide equipment that is equivalent in all respects to specified fixtures. Lighting fixtures as shown on the drawings or specified herein shall be used as a basis and standard of comparison in the review and consideration of fixtures

of other manufacturers. The Architect/Engineer shall have the final authority as to whether the fixture is equivalent to the specified item. The proposed substitution may be rejected for the aesthetic value if felt necessary or desirable. In the event the proposed substitutions are rejected, the Contractor shall furnish the specified item.

2.3 LED Drivers

A. Driver shall operate from 60 Hz input source of 120V through 277V with sustained variations of +/- 10 percent (voltage and frequency).

B. Driver input current shall have Total Harmonic Distortion (THD) of less than 20 percent when operated at nominal line voltage.

C. Driver shall have a Power Factor greater than 0.90.

D. Driver shall avoid interference with infrared devices and eliminate visible flicker.

E. Driver shall comply with ANSI C62.41 Category A for Transient protection.

F. Driver shall comply with the requirements of the Federal Communications Commission (FCC) rules and regulations, Title 47 CFR part 18, Non-Consumer (Class A) for EMI/RFI (conducted and radiated).

G. The luminaire shall be capable of continuous dimming over a range of 100% to 5% of rated lumen output. Dimming shall be controlled by a 0-10VDC signal.

H. Control device must be compatible with type of driver, and coordinated prior to submission of shop drawings.

I. If driver is remote-mounted, provide maximum allowable distances for secondary wire runs to luminaires.

J. Provide with mounting hardware as required.

2.4 LED's

A. Color temperature specified shall be uniform for all LED modules within like luminaire types. Color temperature measurement shall have a maximum 2 SDCM on the MacAdam Ellipse.

B. Correlated color temperature as shown on plan. Minimum color rendering index (CRI) of 85.

C. LED light output and efficacy shall be measured in accordance with IES LM-79 standards.

D. LED life and lumen maintenance shall be measured in accordance with IES LM-80 standards.

E. Rated minimum life of 50,000 hours.

F. The individual LED's shall be connected such that a catastrophic loss or the failure of one LED will not result in a light output loss of the entire luminaire.

2.5 PLASTER FRAMES

A. Standard plaster frames shall be provided for all recessed lighting fixtures installed in plaster or drywall finished walls or ceilings. Coordinate with architectural drawings.

2.6 THERMAL PROTECTION

A. All recessed fixtures shall be provided with thermal protection per N.E.C requirements.

3. EXECUTION

3.1 INSTALLATION

A. Install lighting fixtures at locations and heights as indicated, in accordance with fixture manufacturer's written instructions, applicable requirements of the NEC, NECA's "Standard of Installation", NEMA standards, and with recognized industry practices to ensure that lighting fixtures fulfill requirements.

B. Coordinate with other electrical work as appropriate to properly interface installation of lighting fixtures with other work.

C. Adjust and Clean: Clean lighting fixtures of dirt and debris upon completion of the installation. Protect installed fixtures from damage during the remainder of the construction period.

D. Field Quality Control: Upon completion of the installation of lighting fixtures, and after building circuits have been energized, apply electrical energy to demonstrate capability and compliance with the requirements. Where possible, correct malfunctioning units at the site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

E. Lighting fixture supports: Properly support and install fixtures in strict accordance with all applicable building codes and standards. Fully and completely coordinate the installation of fixtures with actual ceiling systems, and with all building trades. In general, provide fixture supports according to the following (unless applicable codes require more restrictive support details):

1. All lighting fixtures installed in grid type suspended ceiling systems, shall be positively attached to the ceiling system with clips that are UL listed for the application. In addition, a minimum of four (4) ceiling support system rods or wires shall be provided for each light fixture and shall be installed not more than six (6) inches from fixture corners. Provide

two (2) No. 12 gage hangers from each fixture housing to the building structure above (wires may be installed slack). Light fixtures that weigh more than 56 pounds shall be supported directly from the structure above by UL listed and approved hangers. Light fixtures that are smaller than the ceiling grid shall be installed at locations indicated on the reflected ceiling plans, or shall be installed in the center of the ceiling panel and shall be supported independently by at least two metal channels that span and are secured to the ceiling system.

2. Suspended lighting fixtures shall be supported directly from the building structure without using suspended ceilings as support systems. Support systems shall be UL listed and approved for the specific installation. Where pendants or rods exceed 48 inches in length, brace support systems to limit swinging.

F. Square and rectangular fixtures shall be mounted with sides parallel to building and ceiling lines, unless otherwise noted.

G. Where special fixtures to be used in special ceilings are scheduled, verify all ceiling system details and coordinate fixture type and accessories prior to ordering fixtures. Coordinate and cooperate with ceiling system supplier in the preparation of ceiling system shop drawings.

H. Install fixtures as recommended by the manufacturer, or as necessary to provide exact horizontal alignment, preventing horizontal or vertical deflection, or angular jointing of fixtures suspended in continuous rows.

END OF SECTION 26 51 00

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SECTION 27 00 00 - TELECOMMUNICATIONS

PART 1. GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this Section.

B. Division 26 "Basic Materials and Methods" sections apply to work specified in this Section.

PART 2. BUILDING WIRING SYSTEM DESIGN

2.1 GENERAL INFORMATION

A. Except for pathway construction, Division of IT will provide all material and equipment. This includes cable, voice/data/catv outlets and faceplates, equipment racks, and electronic equipment and all miscellaneous hardware.

B. The contractor will install owner-provided cable.

C. Cables do not need to be labeled by the contractor.

D. Division of IT will terminate, label and test all cabling and install all electronic equipment.

E. Cat6A shall be installed directionally from the telecom room outward.

PART 3. HORIZONTAL PATHWAYS AND SPACES

3.1 GENERAL INFORMATION

A. To avoid electromagnetic interference (EMI), all pathways shall provide clearances of at least 4 feet from motors or transformers, 1 foot from conduit and cables used for electrical power distribution, 5 inches from fluorescent lighting.

B. Horizontal Pathways:

1. Pathways must support cables and provide protection. Pathways should be planned to facilitate original installation as well as ongoing maintenance, additions, and relocations.
2. Conduit, trays, or other pathway hardware are to be used above the ceilings. Appropriate installation of horizontal pathways should prevent the hanging of cables loosely above

suspended ceilings. Contractor shall provide appropriate hardware (J-hooks, rings, etc.). Support hardware must not have sharp edges.

3. Cable trays should have twelve (12) inches of clearance above the tray. The contractor/installer should ensure that other building components (e.g., lighting fixtures, structural supports, air ducts) do not restrict access to the cable tray.
4. Cable routing, support, and sealing of penetrations must meet applicable UMC codes.
5. EZ Path series 44 fire wall sleeves are requires where a cable tray path crosses a firewall. The quantity of EZ Path series 44 fittings will equal the capacity of the cable tray, not just the initial cabling demands.
6. Conduit, cable tray, and J-hooks will be designed to allow a 40% growth.
7. Hanging cable supports must be no more than 5 feet apart as the installed cable must exhibit some sag in hanging. This provides visual evidence that cable tension is within 25 pounds as required in EIA-568-A.
8. Bundles of cables supported by typical J-hooks should not be larger than 50 cables, unless additional support is provided.
9. Horizontal pathway installation should take into consideration the horizontal cabling distance limitations of 90 meters (295 feet) from the telecommunications room to the outlet.
10. When conduit is used, sections of conduit shall be no longer than 150 ft and must not have more than or the equivalent of 270° bends between pull points or pull boxes.
11. Conduit inside bend radius must be:

Conduit size…	Bend radius…
2” or less	Six times the inside diameter
More than 2”	Ten times the inside diameter

12. Pull boxes should be placed directly after a bend or sized accordingly if the pull box is located at the bend.
13. Conduit fill limits must be followed to avoid over-packing cables:

Conduit Size…	# of cables…
1”	3 cables max
1-1/4”	4 cables max
1-1/2”	6 cables max
2”	12 cables max
3”	20 cables max

14. Dual channel raceway such as Wiremold 4000 a decora (GFCI) style device plate opening.
15. When possible, outlet locations should be placed above the work surfaces for easy access. Outlet boxes built into the floor are not recommended.
16. Cabling shall be supported above drop ceilings completely by cable tray or J-hooks.
17. Above hard lid, non-accessible ceilings, all cabling shall be installed in conduit.

PART 4. CABLING INSTALLATION AND DISTRIBUTION

4.1 CABLE TYPE, SOURCE OF MATERIALS, AND ASSIGNMENT OF TASKS

A. All vertical and horizontal in-building cable shall be plenum rated.

B. All cable will terminate in a telecom room on the same floor as the outlet.

C. Division of IT will install all backbone cable and perform terminating and testing of such facilities.

D. The contractor shall install owner provided cabling as specified for the project. The Division of IT will terminate and test all contractor installed cabling. Division of IT will provide all materials including cable, connecting hardware, terminals, equipment racks, etc.

E. The contractor/installer shall take into account the following critical installation practices when installing telecommunications cabling.

1. Physical separation from all sources of EMI is critical. Sources of EMI include but are not limited to: motors, transformers, copiers, construction equipment, and branch circuit power cables. Cabling that leaves physical pathways and extends into office areas must not lay on fluorescent lighting.
2. Conduit or other raceway pulling tensions should be minimized using suitable equipment and practices.
3. Cables must not lie on or be suspended from suspended ceiling support wires or frames.
4. Eliminate cable stress caused by tension in suspended cable runs. Cables must exhibit some sag in hanging between supports. Hanging supports, such as J-hooks, must be within 5 feet of each other.
5. Cables bundles should not be larger than 50 cables and shall not be tightly cinched together. Tie wraps must be hand tightened without tools. Cables must never be twisted.
6. Installations of CAT6A cable should have bend radii less than six (6) times the cable diameter. For fiber optic cable, the minimum recommended bend radius is ten (10) times the cable diameter, twenty (20) times the cable diameter if loaded.
7. Cables shall not be spliced under any circumstances. Damaged or broken cables must be completely replaced or decommissioned with a label attached at both ends.
8. Conduits should not be daisy chained together.
9. Provide adequate slack at both ends to accommodate terminations, unless otherwise noted on plans, provide:

Location…	**Slack length…**
Outlet	18 inches
Telecom Room	20 feet past termination point

END OF SECTION 27 00 00

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SECTION 28 31 11 – ADDRESSABLE FIRE ALARM SYSTEM

1. GENERAL

1.1 SUMMARY

A. AS A PART OF THIS PROJECT, THE EXISTING FIRE ALARM SYSTEM (Honeywell FCI) SHALL BE EXPANDED AS NECESSARY TO SERVE THE AREA OF RENOVATION. THE FOLLOWING SPECIFIES THE PERFORMANCE REQUIRMENTS FOR NEW DEVICES AND EQUIPMENT. ALL NEW COMPONENTS MUST BE FULLY AND COMPLETELY COMPATIBLE WITH THE EXISTING SYSTEM. IN ADDITION, THE CONTRACTOR SHALL PROVIDE ALL REQUIRED COMPONENTS TO EXPAND THE SYSTEM AS INDICATED.

B. Work covered by this section includes the furnishing of labor, equipment, and materials for installation of the fire alarm system as indicated on the drawings and specifications.

1.2 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with requirements, provide alternate products by one of the following:

1. Honeywell FCI

B. The Manufacturer shall be a nationally recognized company specializing in fire alarm and detection systems. This organization shall employ factory trained and NICET certified technicians, and shall maintain a service organization within 100 miles of this project location. The Manufacturer and service organization shall have a minimum of 10 years experience in the fire protective signaling systems industry.

C. Being listed as an acceptable Manufacturer in no way relieves obligation to provide all equipment and features in accordance with these specifications.

1.3 RELATED DOCUMENTS

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

B. The work covered by this section is to be coordinated with related work as specified elsewhere in the specifications. Requirements of the following sections apply:

1. Division 26: "Basic Electrical Materials and Methods."
2. Division 26: "Wiring Methods."

C. The system and all associated operations shall be in accordance with the following:

1. Guidelines of the following Building Code: IBC
2. IFC
3. NFPA 72, National Fire Alarm Code
4. NFPA 70, National Electrical Code

5. NFPA 101, Life Safety Code
6. NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems
7. Other applicable NFPA standards
8. Local Jurisdictional Adopted Codes and Standards
9. ADA Accessibility Guidelines

1.4 SYSTEM DESCRIPTION

A. General: Provide a complete, non-coded, addressable, microprocessor-based, **horn-based** fire alarm system with initiating devices, notification appliances, and monitoring and control devices as indicated on the drawings and as specified herein.

B. Wiring/Signal Transmission:

1. Transmission shall be hard-wired, using separate individual circuits for addressable signal transmission, dedicated to fire alarm service only].
2. System connections for initiating SLC circuits and notification appliance circuits.
3. Circuit Supervision: Circuit faults shall be indicated by a trouble signal at the FACP. Provide a distinctive indicating audible tone and alphanumeric annunciation.

C. Analog Smoke Sensors:

1. Monitoring: FACP shall individually monitor sensors for calibration, sensitivity, and alarm condition, and shall individually adjust for sensitivity. The control unit shall determine the condition of each sensor by comparing the sensor value to the stored values.
2. Environmental Compensation: The FACP shall maintain a moving average of the sensor's smoke chamber value to automatically compensate for dust, dirt, and other conditions that could affect detection operations.
3. Programmable Sensitivity: Photoelectric Smoke Sensors shall have 7 sensitivity levels ranging from 0.2% to 3.7%, programmed and monitored from the FACP.
4. Sensitivity Testing Reports: The FACP shall provide sensor reports that meet NFPA 72 calibrated test method requirements. The reports shall be viewed on a video display or printed for annual recording and logging of the calibration maintenance schedule.
5. The FACP shall automatically indicate when an individual sensor needs cleaning. The system shall provide a means to indicate that a sensor requires cleaning. When a sensor's average value reaches a predetermined value, (3) progressive levels of reporting are provided. The first level shall indicate that a sensor is close to a trouble reporting condition and will be indicated on the FACP as "ALMOST DIRTY." This condition provides a means to alert maintenance staff of a dirty sensor without creating a trouble in the system. If this indicator is ignored, a second level "DIRTY SENSOR" condition shall be indicated at the FACP and subsequently a system trouble is reported to the Central Monitoring Station. The sensor base LED shall glow steady giving a visible indication at the sensor location. The "DIRTY SENSOR" condition shall not affect the sensitivity level required to alarm the sensor. If a "DIRTY SENSOR" is left unattended, and its average value increases to a third predetermined value, an "EXCESSIVELY DIRTY SENSOR" trouble condition shall be indicated at the control unit.

6. The FACP shall continuously perform an automatic self-test on each sensor which will check sensor electronics and ensure the accuracy of the values being transmitted. Any sensor that fails this test shall indicate a "SELF TEST ABNORMAL" trouble condition.
7. Programmable bases. It shall be possible to program relay and sounder bases to operate independently of their associated sensor.
8. Magnet test activation of smoke sensors shall be distinguished by its label and history log entry as being activated by a magnet.

D. Smoke Detectors: A maintenance and testing service providing the following shall be included with the base bid:

1. Biannual sensitivity reading and logging for each smoke sensor.
2. Scheduled biannual threshold adjustments to maintain proper sensitivity for each smoke sensor.
3. Threshold adjustment to any smoke sensor that has alarmed the system without the presence of particles of combustion.
4. Scheduled biannual cleaning or replacement of each smoke detector or sensor within the system.
5. Semi-annual functional testing of each smoke detector or sensor using the manufacturer's calibrated test tool.
6. Written documentation of all testing, cleaning, replacing, threshold adjustment, and sensitivity reading for each smoke detector or sensor device within the system.
7. The initial service included in the bid price shall provide the above listed procedures for a period of five years after owner acceptance of the system.

E. Audible Alarm Notification: By tone signals on horns in areas as indicated on drawings.

F. Visual Alarm Notification: By xenon flash tube signal on fire alarm strobe devices in areas as indicated on drawings.

G. Fire Suppression Monitoring:

1. Water flow: Activation of a water flow switch shall initiate general alarm operations.
2. Sprinkler/Stand Pipe valve tamper switch: The activation of any valve tamper switch shall activate system supervisory operations.
3. WSO: Water flow switch and sprinkler/stand pipe valve tamper switch shall be capable of existing on the same initiating zone. Activation of either device shall distinctly report which device is in alarm on the initiating zone.

H. Power Requirements

1. The control unit shall receive AC power via a dedicated branch circuit.
2. The system shall be provided with sufficient battery capacity to operate the entire system upon loss of normal AC power in accordance with code requirements. All battery charging and recharging operations shall be automatic.
3. All circuits requiring system-operating power shall be 24 VDC and shall be individually fused at the control unit.

4. The incoming power to the system shall be supervised so that any power failure will be indicated at the control unit. A green "power on" LED shall be displayed continuously while incoming power is present.
5. The system batteries shall be supervised so that a low battery or depleted battery condition or disconnection of the battery shall be indicated at the control unit and displayed for the specific fault type.
6. The system shall support NAC Lockout feature to prevent subsequent activation of Notification Appliance Circuits after a Depleted Battery condition occurs in order to make use of battery reserve for front panel annunciation and control
7. The system shall support 100% of addressable devices in alarm or operated at the same time, under both primary (AC) and secondary (battery) power conditions.
8. All notification circuits shall have a minimum of 20% spare current draw capacity for future devices. At a minimum, each floor shall be on its own circuit. Provide additional circuits per floor as required to accommodate actual number of devices shown on plan.
9. Loss of primary power shall sound a trouble signal at the FACP. FACP shall indicate when the system is operating on an alternate power supply.

1.5 SUBMITTALS

A. General: Submit the following according to Conditions of Contract and Division 1 Specification Sections.

1. Product data sheets for system components highlighted to indicate the specific products, features, or functions required to meet this specification. Alternate or as-equal products submitted under this contract must provide a detailed line-by-line comparison of how the submitted product meets, exceeds, or does not comply with this specification.
2. Wiring diagrams from manufacturer.
3. Shop drawings showing system details including location of FACP, all devices, circuiting and details of annunciator. All notification circuits shall have a minimum of 20% spare current draw capacity for future devices.
4. System Power and battery charts with performance graphs and voltage drop calculations to assure that the system will operate per the prescribed backup time periods and under all voltage conditions per UL and NFPA standards.
5. System operation description including method of operation and supervision of each type of circuit and sequence of operations for all manually and automatically initiated system inputs and outputs. A list of all input and output points in the system shall be provided with a label indicating location or use of IDC, NAC, relay, sensor, and auxiliary control circuits.
6. Operation and maintenance data for inclusion in Operating and Maintenance Manual. Include data for each type product, including all features and operating sequences, both automatic and manual. Provide the names, addresses, and telephone numbers of service organizations.
7. Product certification signed by the manufacturer of the fire alarm system components certifying that their products comply with indicated requirements.
8. Record of field tests of system.

B. Submission to Authority Having Jurisdiction: In addition to routine submission of the above material, make an identical submission to the authority having jurisdiction. Include copies of

shop drawings as required to depict component locations to facilitate review. Upon receipt of comments from the Authority, make resubmissions if required to make clarifications or revisions to obtain approval.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A factory authorized installer is to perform the work of this section.

B. Each and all items of the Fire Alarm System shall be listed as a product of a single fire alarm system manufacturer under the appropriate category by Underwriters Laboratories, Inc. (UL), and shall bear the "UL" label.

2. PRODUCTS

2.1 EMERGENCY POWER SUPPLY

A. General: Components include battery, charger, and an automatic transfer switch.

B. Battery: Sealed lead-acid. Provide sufficient capacity to operate the complete alarm system in normal or supervisory (non-alarm) mode for a period of time in accordance with code requirements and as follows:

1. Batteries must be capable of operating the system in normal mode for 24 hours with sufficient capacity to operate the panel in alarm mode for 15 minutes at the end of that 24 hour period.

C. Battery size shall be a minimum of 125% of the calculated size.

2.2 ADDRESSABLE MANUAL PULL STATIONS

A. Description: Addressable single-action type, red LEXAN, with molded, raised-letter operating instructions of contrasting color. Station will mechanically latch upon operation and remain so until manually reset by opening with a key common with the control units.

B. Protective Shield: Provide a tamperproof, clear LEXAN shield and red frame that easily fits over manual pull stations. When shield is lifted to gain access to the station, a battery powered piercing warning horn shall be activated. The horn shall be silenced by lowering and realigning the shield. The horn shall provide 85dB at 10 feet and shall be powered by a 9 VDC battery.

2.3 ADDRESSABLE SMOKE SENSORS

A. General: Comply with UL 268, "Smoke Detectors for Fire Protective Signaling Systems." Include the following features:

1. Factory Nameplate: Serial number and type identification.
2. Operating Voltage: 24 VDC, nominal.
3. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore normal operation.

4. Plug-In Arrangement: Sensor and associated electronic components are mounted in a module that connects to a fixed base with a twist-locking plug connection. Base shall provide break-off plastic tab that can be removed to engage the head/base locking mechanism. No special tools shall be required to remove head once it has been locked. Removal of the detector head shall interrupt the supervisory circuit of the fire alarm detection loop and cause a trouble signal at the control unit.
5. Each sensor base shall contain an LED that will flash each time it is scanned by the Control Unit. In alarm condition, the sensor base LED shall be on steady.
6. Each sensor base shall contain a magnetically actuated test switch to provide for easy alarm testing at the sensor location.
7. Each sensor shall be scanned by the Control Unit for its type identification to prevent inadvertent substitution of another sensor type. Upon detection of a "wrong device", the control unit shall operate with the installed device at the default alarm settings for that sensor; 2.5% obscuration for photoelectric sensor, 135-deg F and 15-deg F rate-of-rise for the heat sensor, but shall indicate a "Wrong Device" trouble condition.
8. The sensor's electronics shall be immune from false alarms caused by EMI and RFI.
9. Sensors include a communication transmitter and receiver in the mounting base having a unique identification and capability for status reporting to the FACP.

B. Type: Smoke sensors shall be of the photoelectric or combination photoelectric / heat type. Where acceptable per manufacturer specifications, ionization type sensors may be used.

C. Bases: Relay output, sounder and isolator bases shall be supported alternatives to the standard base.

D. Duct Smoke Sensor: Photoelectric type, with sampling tube of design and dimensions as recommended by the manufacturer for the specific duct size and installation conditions where applied. In ducts with air-duct velocities lower than 100 feet per minute (transfer ducts, large air plenums, etc.) the detector shall have an air-duct velocity range of 0-3000 feet per minute. Coordinate all air velocity ranges with the Division 23 Contractor. Sensor includes relay as required for fan shutdown.

1. Environmental compensation, programmable sensitivity settings, status testing, and monitoring of sensor dirt accumulation for the duct sensor shall be provided by the FACP.
2. The Duct Housing shall provide a supervised relay driver circuit for driving up to 15 relays with a single "Form C" contact rated at 7A@ 28VDC or 10A@ 120VAC. This auxiliary relay output shall be fully programmable. Relay shall be mounted within 3 feet of HVAC control circuit.
3. Duct Housing shall provide a relay control trouble indicator Yellow LED.
4. Duct Housing shall have a transparent cover to monitor for the presence of smoke. Cover shall secure to housing by means of four (4) captive fastening screws.
5. Duct Housing shall provide two (2) Test Ports for measuring airflow and for testing. These ports will allow aerosol injection in order to test the activation of the duct smoke sensor.
6. Housing shall provide a magnetic test area and Red sensor status LED.
7. For maintenance purposes, it shall be possible to clean the duct housing sampling tubes by accessing them through the duct housing front cover.
8. Each duct sensor shall have a Remote Test Station with an alarm LED and test switch.

9. Where indicated a NEMA 4X weatherproof duct housing enclosure shall provide for the circulation of conditioned air around the internally mounted addressable duct sensor housing to maintain the sensor housing at its rated temperature range. The housing shall be UL Listed to Standard 268A.
10. Detector shall have dry contacts for connection to BMS system.

2.4 ADDRESSABLE HEAT SENSORS

A. Thermal Sensor: Combination fixed-temperature and rate-of-rise unit with plug-in base and alarm indication lamp; 135-deg F fixed-temperature setting except as indicated.

B. Thermal sensor shall be of the epoxy encapsulated electronic design. It shall be thermistor-based, rate-compensated, self-restoring and shall not be affected by thermal lag.

C. Sensor fixed temperature sensing shall be independent of rate-of-rise sensing and] programmable to operate at 135-deg F or 155-deg F. Sensor rate-of-rise temperature detection shall be selectable at the FACP for either 15-deg F or 20-deg F per minute.

D. Sensor shall have the capability to be programmed as a utility monitoring device to monitor for temperature extremes in the range from 32-deg F to 155-deg F.

2.5 ADDRESSABLE CIRCUIT INTERFACE MODULES

A. Addressable Circuit Interface Modules: Arrange to monitor one or more system components that are not otherwise equipped for addressable communication. Modules shall be used for monitoring of waterflow, valve tamper, non-addressable devices, and for control of evacuation indicating appliances and AHU systems.

B. Addressable Circuit Interface Modules will be capable of mounting in a standard electric outlet box. Modules will include cover plates to allow surface or flush mounting. Modules will receive their operating power from the signaling line or a separate two wire pair running from an appropriate power supply as required. The two-wire signaling line circuit shall supply power and communications to the module.

C. There shall be the following types of modules:

1. Type 1: Monitor Circuit Interface Module:

   a. For conventional 2-wire smoke detector and/or contact device monitoring with Class B or Class A wiring supervision. The supervision of the zone wiring will be Class B. This module will communicate status (normal, alarm, trouble) to the FACP.
   b. For conventional 4-wire smoke detector with Class B wiring supervision. The module will provide detector reset capability and over-current power protection for the 4-wire detector. This module will communicate status (normal, alarm, trouble) to the FACP.

2. Type 2: Monitor Circuit Interface Module

a. This type of module is an individually addressable module that has both its power and its communications supplied by the two wire multiplexing signaling line circuit. It provides location specific addressability to an initiating device by monitoring normally open dry contacts. This module shall have the capability of communicating four zone status conditions (normal, alarm, current limited, trouble) to the FACP.
b. This module shall provide location specific addressability for up to five initiating devices by monitoring normally closed or normally open dry contact security devices. The module shall communicate four zone status conditions (open, normal, abnormal, and short).

3. Type 3: Single Address Multi-Point Interface Modules

a. This multipoint module shall provide location specific addressability for four initiating circuits and control two output relays from a single address. Inputs shall provide supervised monitoring of normally open, dry contacts and be capable of communicating four zone status conditions (normal, open, current limited, and short). The input circuits and output relay operation shall be controlled independently and disabled separately.
b. This dual point module shall provide a supervised multi-state input and a relay output, using a single address. The input shall provide supervised monitoring of two normally open, dry contacts with a single point and be capable of communicating four zone status conditions (normal, open, current limited, and short). The two-wire signaling line circuit shall supply power and communications to the module.
c. This dual point module shall monitor an unsupervised normally open, dry contact with one point and control an output relay with the other point, using a single address. The two-wire signaling line circuit shall supply power and communications to the module.

4. Type 4: Control Circuit Interface Module

a. This module shall provide control and status tracking of a Form "C" contact. The two-wire signaling line circuit shall supply power and communications to the module.

5. Type 5: 4-20 mA Analog Monitor Circuit Interface Module

a. This module shall communicate the status of a compatible 4-20 mA sensor to the FACP. The FACP shall annunciate up to three threshold levels, each with custom action message; display and archive actual sensor analog levels; and permit sensor calibration date recording.

D. All Circuit Interface Modules shall be supervised and uniquely identified by the control unit. Module identification shall be transmitted to the control unit for processing according to the program instructions. Modules shall have an on-board LED to provide an indication that the module is powered and communicating with the FACP. The LEDs shall provide a

troubleshooting aid since the LED blinks on poll whenever the peripheral is powered and communicating.

2.6 MAGNETIC DOOR HOLDERS

A. Description: Units shall be listed to UL 228. Units are equipped for wall or floor mounting as indicated and are complete with matching door plate. Unit shall operate from a 120VAC, a 24VAC or a 24VDC source, and develops a minimum of 25 lbs. holding force.

B. Material and Finish: Match door hardware.

2.7 ALARM NOTIFICATION APPLIANCES **(match existing color)**

A. Notification Appliances: The Contractor shall furnish and install Notification Appliances and accessories to operate on compatible signaling line circuits (SLC).

1. Notification appliance operation shall provide power, supervision and separate control of horns and strobes over a single pair of wires. The controlling channel (SLC) digitally communicates with each appliance and receives a response to verify the appliance's presence on the channel. The channel provides a digital command to control appliance operation. SLC channel wiring shall be unshielded twisted pair (UTP), with a capacitance rating of less than 60pf/ft and a minimum 3 twists (turns) per foot.
2. Class B (Style 4) notification appliances shall be wired without requiring traditional in/out wiring methods; addressable "T" Tapping shall be permitted. Up to 63 appliances can be supported on a single channel.
3. Each notification appliance shall contain an electronic module. This on-board module shall allow the channel to perform appliance diagnostics that assist with installation and subsequent test operations. A visible LED on each appliance shall provide verification of communications.

B. Audible: Horn shall be listed to UL 464. Horn appliances shall have a High/Lo Setting, programmable by channel from the controller or by appliance from the host FACP. The horn shall have a minimum sound pressure level of 83 or 89 dBA @ 24VDC. The horn shall mount directly to a standard single gang, double gang or 4" square electrical box, without the use of special adapter or trim rings. Appliances shall be wired with UTP conductors, having a minimum of 3 twists per foot.

C. Visible/Only: Strobe shall be listed to UL 1971. The V/O shall consist of a xenon flash tube and associated lens/reflector system. The V/O enclosure shall mount directly to standard single gang, double gang or 4" square electrical box, without the use of special adapters or trim rings. Appliances shall be wired with UTP conductors, having a minimum of 3 twists per foot. V/O appliances shall be provided with different minimum flash intensities of 15cd, 75cd and 110cd. Provide a label inside the strobe lens to indicate the listed candela rating of the specific Visible/Only appliance.

D. Audible/Visible: Combination Audible/Visible (A/V) Notification Appliances shall be listed to UL 1971 and UL 464. The strobe light shall consist of a xenon flash tube and associated lens/reflector system. Provide a label inside the strobe lens to indicate the listed candela rating

of the specific strobe. The horn shall have a minimum sound pressure level of 83 or 89 dBA @ 24VDC. The audible/visible enclosure shall mount directly to standard single gang, double gang or 4" square electrical box, without the use of special adapters or trim rings. Appliances shall be wired with UTP conductors, having a minimum of 3 twists per foot. The appliance shall be capable of two-wire synchronization with one of the following options:

1. Synchronized Strobe with Horn on steady
2. Synchronized Strobe with Temporal Code Pattern on Horn
3. Synchronized Strobe with March Time cadence on Horn
4. Synchronized Strobe firing to NAC sync signal with Horn silenced

E. Isolator Module: Isolator module provides short circuit isolation for notification appliance SLC wiring. Isolator shall be listed to UL 864. The Isolator shall mount directly to a minimum 2 1/8" deep, standard 4" square electrical box, without the use of special adapter or trim rings. Power and communications shall be supplied by the Controller channel SLC; dual port design shall accept communications and power from either port and shall automatically isolate one port from the other when a short circuit occurs. The following functionality shall be included in the Isolator module:

1. Report faults to the host FACP.
2. On-board Yellow LED provides module status.
3. After the wiring fault is repaired, the Isolator modules shall test the lines and automatically restore the connection.

F. Accessories: The contractor shall furnish the necessary accessories.

2.8 NAC Power Extender

A. The Controller shall be a stand-alone panel capable of powering a minimum of 3 Signaling line circuits. Each channel shall be rated for 2.5 amps and support up to 63 notification appliances. Power and communication for the notification appliances shall be provided on the same pair of wires.

B. SLC notification appliance circuits shall be Class B Style 4.

C. The internal power supply & battery charger shall be capable of charging up 12.7 Ah batteries internally mounted or 18Ah batteries mounted in an external cabinet.

D. The NAC extender panel may be mounted close to the host control panel or can be remotely located.

3. EXECUTION

3.1 INSTALLATION, GENERAL

A. Install system components and all associated devices in accordance with applicable NFPA Standards and manufacturer's recommendations.

B. Installation personnel shall be supervised by persons who are qualified and experienced in the installation, inspection, and testing of fire alarm systems. Examples of qualified personnel shall include, but not be limited to, the following:

1. Factory trained and certified personnel.
2. National Institute of Certification in Engineering Technologies (NICET) fire alarm level II certified personnel.
3. Personnel licensed or certified by state or local authority.

3.2 EQUIPMENT INSTALLATION

A. Furnish and install a complete Fire Alarm System as described herein and as shown on the plans. Include sufficient control unit(s), annunciator(s), manual stations, automatic fire detectors, smoke detectors, audible and visible notification appliances, wiring, terminations, electrical boxes, and all other necessary material for a complete operating system.

B. Water-Flow and Valve Supervisory Switches: Connect for each sprinkler/stand pipe valve required to be supervised.

C. Device Location-Indicating Lights: Locate in the public space immediately adjacent to the device they monitor.

3.3 WIRING INSTALLATION

A. System Wiring: Wire and cable shall be a type listed for its intended use by an approval agency acceptable to the Authority Having Jurisdiction (AHJ) and shall be installed in accordance with the appropriate articles from the current approved edition of NFPA 70: National Electric Code (NEC).

B. Contractor shall obtain from the Fire Alarm System Manufacturer written instruction regarding the appropriate wire/cable to be used for this installation. No deviation from the written instruction shall be made by the Contractor without the prior written approval of the Fire Alarm System Manufacturer.

C. Color Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color code for alarm initiating device circuits wiring and a different color code for supervisory circuits. Color-code notification appliance circuits differently from alarm-initiating circuits. Paint fire alarm system junction boxes and covers red.

D. Install all fire alarm system wiring in red conduit.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Services: Provide services of a factory-authorized service representative to supervise the field assembly and connection of components and the pretesting, testing, and adjustment of the system.

B. Service personnel shall be qualified and experienced in the inspection, testing, and maintenance of fire alarm systems. Examples of qualified personnel shall be permitted to include, but shall not be limited to, individuals with the following qualifications:

1. Factory trained and certified.
2. National Institute for Certification in Engineering Technologies (NICET) fire alarm certified.
3. International Municipal Signal Association (IMSA) fire alarm certified.
4. Certified by a state or local authority.
5. Trained and qualified personnel employed by an organization listed by a national testing laboratory for the servicing of fire alarm systems.

C. Pretesting: Determine, through pretesting, the conformance of the system to the requirements of the Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new and retest until satisfactory performance and conditions are achieved.

D. Final Test Notice: Provide a 10-day minimum notice in writing when the system is ready for final acceptance testing.

E. Minimum System Tests: Test the system according to the procedures outlined in NFPA 72.

F. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets the Specifications and complies with applicable standards.

G. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log.

H. Final Test, Certificate of Completion, and Certificate of Occupancy:

1. Test the system as required by the Authority Having Jurisdiction in order to obtain a certificate of occupancy.

3.5 CLEANING AND ADJUSTING

A. Cleaning: Remove paint splatters and other spots, dirt, and debris. Clean unit internally using methods and materials recommended by manufacturer.

B. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels and adjusting controls and sensitivities to suit actual occupied conditions. Provide up to three visits to the site for this purpose.

END OF SECTION 28 31 11

SECTION 28 55 00 – RF SURVEY FOR IN-BUILDING TWO-WAY EMERGENCY RESPONDER COMMUNICATION ENHANCEMENT SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

1. The purpose of this specification is to establish the requirements and standards for initial survey for public safety radio signal strength per NFPA and IFC

2. Survey should be performed after the building is substantially completed, and prior to start of installation of electrical wiring.

3. Conduct a survey using a RF Spectrum Analyzer, a calibrated, system-compatible radio or another suitable instrument with traceable certificate of calibration to analyze the RF signal strength of Emergency Responder Radio Signal into the building and determine if amplification of the signal is required. Both inbound and outbound signal strength shall be determined, measured, calculated and documented as required by code.

1.2 SURVEY CRITERIA IF REQUIRED

1. The required Public Safety Radio Signal Level inside the Owner's facility must be determined per code, ordinance or AHJ

2. The minimum qualifications of the system designer and lead installation personnel shall include both of the following:

    1. A valid FCC-issued general radio operators license.
    2. Certification of in-building system training issued by a nationally recognized organization, school or a certificate issued by the manufacturer of the equipment being installed.

1.3 REGULATIONS

1. Codes, regulations and standards referenced in the Section are:

    1. NFPA 1 – The National Fire Code (including Annex O from 2009)
    2. NFPA 70 – The National Electrical Code
    3. IFC 510- Emergency Responder Radio Coverage
    4. NFPA 101, Life Safety Code, the Ohio Building Code, and Local Code and Building Authority requirements.
    5. NFPA 72 National Fire Alarm Code
    6. FCC 47 CFR Private Land Mobile Radio
    7. 90.219 Services-Use of Signal Boosters

8. ICC International Fire Code, Code and Commentary
9. Local or State Promulgated Fire Code
10. ADA "Americans with Disabilities Act"
11. FCC's OET 65 Standards "Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields"
12. FCC Rules Part 22, Part 90 and Part 101
13. NFPA 1221 2016 Edition or later
14. International Building Code 2012 / 2015 / 2018 or later
15. UL 2524 2nd Edition

1.4 DEFINITIONS

1. Definitions:

1. Bi-Directional Amplifier BDA / Fiber DAS Master/Remote: Device used to amplify band-selective or multi-band RF signals in the uplink, to the base station and in the downlink from the base station to subscriber devices for enhanced signals and improved coverage.
2. In-building Two-way Emergency Responder Communication Enhancement System: A two-way radio communication system installed to assure the effective operation of radio communications systems for fire, emergency medical services, or law enforcement agencies within a building or structure. A system used by firefighters, police, and other emergency services personnel.
3. FCC: Federal Communications Commission
4. OET 65 Standards: FCC's Bulletin 65 provides Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields.
5. Public Safety/First Responder: Public Safety or First Responder agencies that are charged with the responsibility of responding to emergency situations. These include, but are not limited to law enforcement departments, fire departments, and emergency medical companies.
6. RSSI: Received signal strength indicator RSSI is a measurement of the power present in a received radio signal.
7. BER: Bit Error Rate is the number of bit errors per unit time
8. GROL- FCC General Radio Operators License
9. ERCES- Emergency Responder Communication Enhancement System
10. DAS-Distributed Antenna System

PART 2. EXECUTION

2.1 TESTING PROCEDURES

1. Minimum Signal Strength: For testing system signal strength and quality, the testing shall be based on the. -95dBm nominal signal at 100%.
2. Spectrum Analyzer or Calibrated Handheld Radio or Scanning Receiver shall be used as basis for signal measurements or other method as approved by AHJ.
3. Testing should be based on a minimum of 20 grid locations per floor OR maximum of 1600 SQ ft. areas if the floor exceeds 32,000 Sq. Ft. Also, testing should include all critical areas

per NFPA. See 1.02 of this specification and NFPA 72 2013 or NFPA 1221 2016. OR per any method determined by the AHJ, local code or ordinance.

4. A minimum signal strength of -95 dBm shall be provided throughout the coverage area for both uplink and downlink by the Local Fire Department.

    a. RSSI measurement only

2.2 SURVEY SUBMITTALS

1. Submit testing data for each level of the building.

    1. An RF measurement drawing of each floor of the building which indicates relative RF field strength for each frequency band of interest must be submitted to the AHJ.
    2. The drawing should indicate clearly the areas that have passed or failed based on the above parameters.

END OF SECTION 28 55 00

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SECTION 311000
SITE CLEARING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
1. Protecting existing vegetation to remain.
2. Removing existing vegetation.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Removing above- and below-grade site improvements.
6. Disconnecting, capping or sealing site utilities.
7. Temporary erosion- and sedimentation-control measures.

1.02 MATERIAL OWNERSHIP

A. Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.03 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

B. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
1. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

C. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.

D. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.

E. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place.

F. The following practices are prohibited within protection zones:
1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Foot traffic.
4. Erection of sheds or structures.
5. Impoundment of water.
6. Excavation or other digging unless otherwise indicated.
7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

PART 2 PRODUCTS

2.01 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 312000 "Earth Moving."
1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

PART 3 EXECUTION

3.01 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Locate and clearly identify trees, shrubs, and other vegetation to remain or to be relocated.

C. Protect existing site improvements to remain from damage during construction.
   1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.02 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control drawings and requirements of authorities having jurisdiction.

B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.

C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

D. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.03 TREE AND PLANT PROTECTION

A. General: Protect trees and plants remaining on-site.

B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner approved by Design Professional.

3.04 EXISTING UTILITIES

A. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place.
   1. Arrange with utility companies to shut off indicated utilities.

B. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
   1. Notify Design Professional not less than two days in advance of proposed utility interruptions.
   2. Do not proceed with utility interruptions without Design Professional's written permission.

3.05 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.
   1. Grind down stumps and remove roots, obstructions, and debris to a depth of 18 inches (450 mm) below exposed subgrade.
   2. Use only hand methods for grubbing within protection zones.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
   1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches (200 mm), and compact each layer to a density equal to adjacent original ground.

3.06 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to depth of 6 inches (150 mm) in a manner to prevent intermingling with underlying subsoil or other waste materials.

C. Stockpile topsoil away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.

3.07 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

3.08 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

B. Separate recyclable materials produced during site clearing from other non-recyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION

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SECTION 312000
EARTH MOVING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
1. Excavation for paving and grading.
2. Excavation for building foundations, slabs-on-grade, paving, and grading.
3. Excavation for Site structures.
4. Site filing and backfilling.
5. Drainage course for slabs-on-grade.
6. Consolidation and compaction.
7. Excavation for trenches for utilities and footings.
8. Consolidation and compaction of bedding under utilities.
9. Rough grading.

B. Related Sections:
1. Section 015713 – Temporary Erosion and Sediment Control.
2. Section 311000 – Site Clearing.
3. Section 331100 - Water Utility Distribution Piping
4. Section 333100 – Sanitary Utility Sewerage Piping
5. Section 334100 – Storm Utility Drainage Piping.
6. Section 334613 – Foundation Drainage.

1.02 DEFINITIONS

A. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials, and bottom of over excavation areas if required by the contract document.

B. Subbase Course: Aggregate layer placed between the subgrade and hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

E. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill, when sufficient approved soil material is not available from excavations.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated, regardless of the character and density of materials, including reuse or disposal of materials removed.
1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Design Professional. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Design Professional. Unauthorized excavation, as well as remedial work directed by Design Professional, shall be without additional compensation.

G. Fill: Suitable materials used to raise existing grades.

H. Finish Grade: The top surface of sod, top surface of topsoil where sod is not indicated or exposed rock surface where indicated on the drawing.

I. Trench Backfill: Soil material or controlled low-strength material used to fill an excavation.
   1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
   2. Final Backfill: Backfill placed over initial backfill to fill a trench.

J. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

K. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

L. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed **1 cu. yd. (0.76 cu. m)** for bulk excavation or **3/4 cu. yd. (0.57 cu. m)** for footing and trench excavation that cannot be removed by rock-excavating equipment equivalent to the following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted:
   1. Equipment for Footing and Trench: Late-model, track-mounted hydraulic excavator; equipped with a 42-inch- (1065-mm-) maximum-width, short-tip-radius rock bucket; rated at not less than 138-hp (103-kW) flywheel power with bucket-curling force of not less than 28,700 lbf (128 kN) and stick-crowd force of not less than 18,400 lbf (82 kN) with extra-long reach boom.
   2. Equipment for Bulk Excavation: Late-model, track-mounted loader; rated at not less than 230-hp (172-kW) flywheel power and developing a minimum of 47,992-lbf (213.3-kN) breakout force with a general-purpose bare bucket.

1.03 SUBMITTALS

A. Submit in accordance with Division 1 unless otherwise indicated.

B. Product Data: For each type of material indicated in Part 2 of this section.

C. Contract Closeout Submittals: Submit in accordance with Division 1.
   1. Project Record Documents.
      a. Accurately record location of underground utilities remaining, rerouted utilities, and new utilities by horizontal dimensions from above grade permanent fixtures, elevations or inverts, and slope gradients.

D. Soil testing reports as required by Section 1.04B

1.04 QUALITY ASSURANCE

A. Installer's Qualifications: Firm experienced in installation of systems similar in complexity to those required for this Project, plus the following:
   1. Not less than 3 years experience with systems.
   2. Successfully completed not less than 5 comparable scale projects using this system.

B. Testing Agency: A qualified independent geotechnical engineering testing agency shall classify proposed on-Site and borrow soils to verify that soils comply with specified requirements and to perform specified field and laboratory testing.

C. Pre-excavation Conference:

1. Convene pre-excavation conference under provision of Division 1, one week prior to commencing Work of this Section.
2. Contractor shall be presiding officer at conference.
3. Conference shall be attended by Contractor, Owner's Representative, testing agency, and earthwork subcontractor.
4. Purpose of conference will be to review contract requirements and discuss schedules, work procedures, acceptable materials specified under this Section, locations where specified materials may be incorporated, and quality control.

1.05 PROJECT CONDITIONS

A. Existing Conditions:
   1. Locate existing underground utilities in areas of excavation Work.
      a. Do not interrupt existing utilities serving facilities occupied by the Owner or others except when permitted in writing by Owner's Representative and then only after acceptable temporary utility services have been provided.
      b. Provide not less than 72 hours notice to Design Professional and Owner's Representative and receive written authorization to proceed before interrupting any utility.

1.06 MAINTENANCE

A. Where settling is measurable or observable at excavated areas during correction period required by General Conditions, remove surface (pavement, lawn, or other finish), add backfill material, compact as specified in this Section for location of material, and replace surface treatment.
   1. Restore appearance, quality, and condition of surface or finish to match adjacent materials.
   2. Eliminate evidence of restoration.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:
   1. Provide approved borrow soil materials from off-Site when sufficient approved soil materials are not available from excavations, at no increase in Contract Sum or extension of Contract Time.
   2. Dispose of any excess materials legally off site at no increase in contract sum or extension of contract time. On site disposal of suitable materials may only be permitted where shown on the drawings.
   3. Fill and backfill materials shall be subject to the approval of testing agency and the Owner's Representative.
   4. For approval of fill and backfill materials, notify testing agency and Owner's Representative at least 5 working days in advance of intention to import material.
      a. Designate proposed borrow area and excavate test pits to permit testing agency to sample as necessary from borrow area for the purpose of making acceptance tests to confirm quality of proposed material.

B. General Fill Materials
   1. Definition: That material used to obtain finish subgrade levels at locations specified under this section.
   2. Acceptable material: Excavated on-Site material or off-Site borrow material which is free from debris, organics, decomposable, and corrodible materials, and containing the proper

moisture content, liquid limit, and plasticity index to obtain specified compaction requirements.

a. Existing on-Site material proposed for reuse, and off-Site borrow material shall be approved by testing agency.

C. Structural Fill and Backfill

1. Engineered fill is defined as crushed limestone aggregate containing sufficient fines to establish moisture/density relationship. Engineered fill shall be free of frozen soil, organics, rubbish, large rocks, wood, or other deleterious material. Cohesive soils shall be uniformly compacted to at least 95 percent of the maximum standard dry density and be within -2 to +3 percent of optimum moisture content as described by ASTM D698. Engineered fill, such as MoDOT Type 5 Aggregate, shall be compacted to at least 95% of the maximum dry density as determined by the Standard Proctor, ASTM D698. The moisture content shall be high enough to provide for proper compaction but low enough to prevent undue pumping. Should the results of the in-place density tests indicate that the specified compaction limits have not been achieved, the area represented by the test shall be reworked and retested as required until the specified limits are reached. Proposed fill shall be analyzed by the geotechnical engineer prior to use.
2. The fill material shall be placed in layers, not to exceed eight inches in loose thickness, and shall be wetted or dried as required to secure specified compaction. Effective spreading equipment shall be used on each lift to obtain a uniform lift thickness prior to compaction. Each layer shall be uniformly compacted by means of suitable equipment of the type required by the materials composing the fill. The fill layers shall be placed approximately parallel to the finished grade.

D. Low Volume Change Material:

1. Definition: That material used to obtain the upper 24 inches of finish subgrade beneath granular base in building areas, and material used as trench backfill material in building areas.
2. Acceptable material:
   a. On-site or Off-Site borrow material which is free from debris, organics, decomposable, and corrodible materials with a liquid limit of less than 40 percent, or another material acceptable to the testing agency.
      1) Existing on-Site material proposed for reuse, and off-Site borrow material shall be approved by testing agency.
   b. MoDOT Type 5 Aggregate

E. Granular Fill:

1. Definition: Free-draining granular base used beneath building slabs-on-grade and used as backfill behind foundation and retaining walls.
2. Acceptable materials: MoDOT Type 1 Aggregate.

F. Pavement Subbase Course:

1. Definition: Granular base used beneath concrete pavement and other pavements indicated on Drawings.
2. Acceptable materials: MoDOT Type 1 Aggregate.

G. Bedding Materials: Type 1 aggregate per MoDOT Standard Specification for Highway Construction, Section 1007.

H. Trench Backfill Materials:

1. Slab on grades: Low volume change materials per this section.
2. Pavement areas: Low volume change material per this section.

3. Other areas: General Fill Material or other materials specified under this Section at locations specified or indicated on Drawings.

I. Backfill Material
1. Definition: Material requiring placement and compaction with manual procedures because of restricted spaces or new construction.
2. Acceptable materials: Either General Fill Material, Granular Fill Material, or other materials specified under this Section at locations specified or indicated on Drawings.

J. Unsuitable Material
1. Definition: That excavated material which does not meet the consistency requirements of any other defined materials in this Section, including muck, frozen material, organic material, top soil, rubbish, and rock within the limits defined for General Fill Material
2. Dispose of unsuitable material off-Site, at no increase in Contract Sum or extension of Contract Time.
a. Submit an acceptable agreement with the property owner on whose property the unsuitable material is placed.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper and timely completion.
1. Verify location and elevations of existing building foundations.
2. Verify location and elevations of existing underground utilities.
3. Verify erosion control systems are in place.
4. Do not proceed until unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Protection:
1. Protect trees, shrubs, lawns, other plant growth, and other features indicated on Drawings to remain.
2. Protect bench marks, monuments, existing structures, existing fences, existing roads, existing sidewalks, existing paving, and existing curbs from damage caused by settlement, lateral movement, undermining, washout, and other hazards caused by Work of this Section.
a. If damaged or displaced, notify Owner's Representative and correct defects as directed by Owner's Representative.
3. Protect above and below grade utilities which are to remain.
4. Protect adjacent and downstream properties from pollution, sedimentation, or erosion caused by the work of this Contract.

B. Precautions:
1. Use all means necessary to control dust on and near the Work, and on and near off-Site borrow storage, and spoil areas, if such dust is caused by performance of the Work of this Section, or if resulting from the condition in which Project Site is left by Contractor.
2. Moisten surfaces as required to prevent dust from being a nuisance to the public, neighbors, and concurrent performance of other Work on Project Site.
3. Identify required lines, levels, contours, and datum.
4. Identify above and below grade utilities.
5. Provide and maintain positive surface drainage.

3.03 WATER CONTROL

A. Provide berms or channels to prevent flooding of subgrades.

B. Prevent infiltration of water into excavations from whatever sources as may exist.

C. Prevent ponding of water on finish subgrades.

D. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

E. Prevent flooding of Project Site and surrounding areas.

F. Promptly remove water collection in depressions.
   1. Provide and maintain ample means and devices with which to remove and dispose of water entering excavations.
   2. Ensure dry excavations and preservation of final lines and grades of bottoms of excavations.

3.04 EXCAVATION, GENERAL

A. Excavation above subgrade as defined in paragraph 1.2 of this section is unclassified and includes excavation of any material encountered regardless of its character including rock, soil materials, debris, and other obstructions and shall be included in the base bid.

B. Perform excavation to the lines and grades indicated on Drawings within a tolerance of 0.10 foot.
   1. Extend excavations a sufficient distance from structures for placing and removing concrete formwork, installing services and other construction, and for inspections.

C. Perform Excavation Work in compliance with applicable requirements of authorities having jurisdiction, including United States Department of Labor, Occupational Safety and Health Administration (OSHA) “Construction Standards for Excavations, 29 CFR Part 1926”.

D. Perform Work in a manner and sequence that will provide drainage at all times and that will prevent surface water from draining into excavations.

E. Protect subgrades and foundation soils against freezing temperatures and frost.
   1. Provide protective insulation materials as necessary.

F. When excavating through roots, perform Work by hand cutting roots with sharp axe.

G. Excavation cut shall not interfere with normal 45 degree bearing splay of foundations.

H. Machine slope banks to comply with local codes, ordinances, and requirements of agencies having jurisdiction.
   1. Provide materials for shoring and bracing.
      a. Maintain shoring and bracing in excavations regardless of time period excavations will be open.
      b. Extend shoring and bracing as excavation progresses
   2. Control surface drainage down slopes.
   3. Cover slopes to prevent loss of moisture content of soil and to prevent raveling.

I. When materials encountered at subgrade are determined to be unacceptable for use by testing agency, remove such material to depths and limits determined by testing agency.
   1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material.

J. Where depressions result from, or have resulted from the removal of surface or subsurface obstructions, open depressions to equipment working width, and remove debris and soft

material as directed by testing agency, at no increase in Contract Sum or extension of Contract time.

1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material, at no increase in Contract Sum or extension of Contract Time.

K. Backfill and compact over-excavations and unauthorized as specified for the area at which it occurs, at no increase in Contract Sum or extension of Contract Time.

1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material, at no increase in Contract Sum or extension of Contract Time.

L. Stockpile excavation material which testing agency has approved for reuse.

1. Stockpile soil materials without intermixing soil materials with different consistencies and gradation.
2. Place, grade, and shape stockpiles to drain surface water.
3. Do not stockpile within drip line of trees which are to remain.
4. Cover stockpiles to prevent wind-blown dust.

M. Remove unacceptable excavation material from Site, at no increase in Contract Sum or extension of Contract Time.

N. Hand trim excavations.

1. Remove loose matter.

O. Excavation for Footings and Foundations:

1. Do not disturb bottom of excavation.
   a. Excavate by hand to final grade immediately prior to placement of concrete reinforcement.
   b. Trim bottom of excavations to required lines and grades to leave solid base to receive other work.
2. Drill probe holes at exposed bottom of excavations as directed by testing agency.

3.05 TRENCH EXCAVATIONS

A. Trench excavation is unclassified and includes excavation to required exposed subgrade elevations regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, debris, and other obstructions.

B. Excavate trenches to gradients, lines, depths, and elevations indicated on Drawings, within a tolerance of 0.10 foot.

C. Perform excavation Work in compliance with applicable requirements of authorities having jurisdiction, including United States Department of Labor, Occupational Safety and Health Administration (OSHA) "Construction Standards for Excavations, 29 CFR Part 1926".

D. Do not perform trench excavation in areas to receive fill until fill operations are complete to an elevation of not less than 24 inches above the top of the proposed pipe or conduit for which the trench is to receive.

E. Perform Work in a manner and sequence that will provide drainage at all times and that will prevent surface water from draining into trenches.

F. Protect subgrades against freezing temperatures and frost.

G. Provide protective insulation materials as necessary.

H. When excavating through roots, perform Work by hand cutting roots with a sharp axe.

I. Excavation cut shall not interfere with normal 45 degree bearing splay of foundations.

J. Excavate trenches to uniform width, sufficiently wide to enable installation of utilities and to allow safe inspection of installed utilities.

K. Excavate trenches 6 inches deeper than bottom of pipe elevation to allow for bedding course
   1. Hand excavate for bell of pipe.
   2. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
   3. Comply with local codes, ordinances, and requirements of agencies having jurisdiction.
   4. Provide materials for shoring and bracing.
      a. Maintain shoring and bracing in trenches regardless of time period trenches will be open.
      b. Extend shoring and bracing as excavation progresses.
   5. Control surface drainage down slopes.
   6. Cover slopes to prevent loss of moisture content of soil and to prevent raveling.
   7. Hand trim trenches.
      a. Remove loose matter.

L. When subgrade materials are encountered which testing agency determines to be unacceptable for use, remove such material to depths and limits determined by testing agency:
   1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material.
   2. Removal and replacement of unacceptable material will be paid on basis of Unit Prices included in the Contract Documents.

M. Where depressions result from, or have resulted from the removal of surface or subsurface obstructions, open depressions to equipment working width, and remove debris and soft material as directed by testing agency at no increase in Contract Sum or extension of Contract Time.
   1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material, at no increase in Contract Sum or extension of Contract Time.

N. Stockpile excavation material which testing agency has approved for reuse.
   1. Stockpile soil materials without intermixing soil materials with different consistencies and gradations.
   2. Place, grade, and shape stockpiles to drain surface water.
   3. Do not stockpile within drip line of trees which are to remain.
   4. Cover stockpiles to prevent wind-blown dust.

O. Remove unacceptable excavation material from Site, at no increase in Contract Sum or extension of Contract Time.
   1. Submit an acceptable agreement with the property owner on whose property the unsuitable material is placed.

3.06 SUBGRADE PREPARATION FOR BUILDING SLABS-ON-GRADE

A. General:
   1. Excavation for subgrade preparation is unclassified and includes excavation to required subgrade elevations regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, debris, and other obstructions.
   2. Testing agency shall be present to observe and evaluate subgrades in building areas prior to placement of fill and/or low volume change materials and shall be present during

placement and compaction of fill materials in building areas. Undercut as specified herein to develop 24 inch thick low volume change zone below building floor slabs. Subgrades in building areas shall be observed and evaluated by geotechnical engineer prior to fill and/or low volume change placement. Evaluation may include probing by geotechnical engineer and opening of test pits and/or test trenches with contractors assistance to explore areas of suspected unsuitable materials. Subgrades shall also be proof-rolled with loaded tandem axle dump truck in presence of geotechnical engineer and scarified, moisture conditioned and recompacted as specified herein prior to placement of fill and/or low volume change materials.

3. Fill material shall not be placed, spread, or rolled while the material is frozen or thawing, or during unfavorable weather conditions.
4. Moisture condition or dry fill material as required to obtain specified moisture content limits.
    a. Material which is too wet to allow proper compaction, as determined by testing agency, may be spread and permitted to dry assisted by disking, harrowing, or pulverizing.
5. Place fill material using spreading equipment capable of obtaining uniform loose lift thickness.
6. Compact fill material using equipment appropriate to the material being compacted, as determined by testing agency.
7. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed fill area is as specified.
8. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.
9. In excavations where testing agency determines that subgrade material is unacceptable, remove unacceptable material and backfill in accordance with procedures determined by testing agency.
10. Minimize construction traffic, including foot traffic, from floor slab finished subgrades in order to prevent unnecessary disturbances of subgrade materials.
    a. If testing agency determines that finished subgrades have been disturbed, remove disturbed areas and replace and recompact to required density as directed by testing agency.
    b. If testing agency determines that rutting has occurred, excavate 6 inches, or other depth as directed by testing agency, of subgrade material and recompact as specified for affected area.
    c. Testing agency shall be present during compaction of material.

B. In cut areas below building slabs-on-grade requiring less than 24 inches of fill to obtain finish subgrade elevations, and a lateral distance of 5 feet outside building areas, excavate existing materials to a depth of not less than 24 inches below bottom of floor slab granular fill.
1. Scarify subgrade to a depth of 6 inches to result in a surface free from ruts, hummocks, and other uneven features which, in the opinion of the testing agency, would prevent uniform compaction by the equipment proposed for use.
    a. Moisture condition subgrade to achieve moisture content specified in this Section.
    b. Compact to a minimum of 95% of the material's maximum Standard Proctor dry density with a moisture content between -2 and +3 percent above optimum moisture content in accordance with ASTM D698.
        1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.

2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

2. After scarifying, moisture conditioning, and recompacting, backfill fill areas using low volume change materials placed in loose lifts not exceeding 8 inches.
   a. Compact each lift of low volume change clay soil to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between -2 and +3 percent above optimum moisture content in accordance with ASTM D698. Compact each lift of granular low volume change material to a minimum of 95 percent of the material's maximum standard proctor dry density at a workable moisture content sufficient to obtain the required density.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
3. Fill operations shall continue in compacted layers until finish subgrade elevations have been obtained.
   a. Compact each lift of low volume change clay soil to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between -2 and +3 percent above optimum moisture content in accordance with ASTM D698. Compact each lift of granular low volume change material to a minimum of 95 percent of the material's maximum standard proctor dry density at a workable moisture content sufficient to obtain the required density.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
4. Protect excavations from excessive wetting and drying during construction.
   a. Remove water entering excavation, and remove disturbed or softened soil.
5. The upper 24 inches of fill material shall be low volume change material.
6. Maintain subgrade moisture content within specified range until building slabs-on-grade are installed.
   a. Rework non-complying area as required to achieve specified requirements as directed by testing agency.
   b. Recompact and retest until required density and moisture content is obtained.

C. In areas below building slabs-on-grade requiring 24 inches or more of fill to obtain finish subgrade elevations, and a lateral distance of 5 feet outside building areas, scarify subgrade to a depth of 6 inches to result in surface free from ruts, hummocks, and other uneven features which, in the opinion testing agency, would prevent uniform compaction by the equipment proposed for use.
   1. Moisture condition subgrade to achieve moisture content specified in this Section.
      a. Compact to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between -2 and +3 percent above optimum moisture content in accordance with ASTM D698.
         1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.

2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

2. After scarifying, moisture conditioning, and recompacting, backfill areas using suitable materials as specified herein placed in loose lifts not exceeding 8 inches. Suitable on-site clay materials may be used below the 24-inch thick low volume change zone.
   a. Compact each lift of suitable clay soil or low volume change material to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between -2 and +3 percent above optimum moisture content in accordance with ASTM D698. Compact each lift of granular low volume change material to a minimum of 95 percent of the material's maximum Standard Proctor dry density at workable moisture content sufficient to obtain the required density.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
3. Fill operations shall continue in compacted layers until finish subgrade elevations have been obtained.
   a. Compact each lift of suitable clay soil or low volume change material to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between -2 and +3 percent above optimum moisture content in accordance with ASTM D698.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
4. Protect excavations from excessive wetting and drying during construction.
   a. Remove water entering excavation, and remove disturbed or softened soil.
5. The upper 24 inches of fill material shall be low volume change material.
6. Maintain subgrade moisture content within specified range until building slabs-on-grade are installed.
   a. Rework non-complying area as required to achieve specified requirements as directed by testing agency.
   b. Recompact and retest until required density and moisture content is obtained.

D. Tolerances:
   1. Top surface of finish subgrade under slabs-on-grade: Plus or minus ¼ inch from required elevations.

3.07 SUBGRADE PREPARATION FOR FOUNDATION FOOTING

A. General:
   1. Excavation for subgrade preparation for foundations is unclassified and includes excavation to required subgrade elevations regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, debris, and other obstructions.
   2. Testing agency shall be present during placement and compaction of fill material.
   3. Fill material shall not be placed, spread, or rolled while the material is frozen or thawing, or during unfavorable weather conditions.

4. Moisture condition dry fill material as required to obtain specified moisture content limits.
   a. Material which is too wet to allow proper compaction, as determined by testing agency, may be spread and permitted to dry assisted by disking, harrowing, or pulverizing.
5. Place fill material using spreading equipment capable of obtaining uniform loose lift thickness.
6. Compact fill material using equipment appropriate to the material being compacted, as determined by testing agency.
7. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed fill area is as specified.
8. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.
9. In excavations where testing agency determines that subgrade material is unacceptable, remove unacceptable material and backfill in accordance with procedures determined by testing agency.
10. Minimize construction traffic, including foot traffic, from floor slab finished subgrades in order to prevent unnecessary disturbances of subgrade materials.
    a. If testing agency determines that finished subgrades have been disturbed, remove disturbed areas and replace and recompact to required density as directed by testing agency.
    b. If testing agency determines that rutting has occurred, excavate 6 inches, or other depth as directed by testing agency, of subgrade material and recompact as specified for affected area.
    c. Testing agency shall be present during compaction of material.

3.08 SUBGRADE PREPARATION AT PAVEMENTS

A. General:
1. Excavation for subgrade preparation is unclassified and includes excavation to required subgrade elevations regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, debris, and other obstructions.
2. Testing agency shall be present to observe proof-rolling of subgrades in pavement and sidewalk areas prior to placement of fill and shall be present during placement and compaction of fill materials in pavement and sidewalk areas. Testing agency shall also be present to observe proof-rolling of finished subgrades prior to installation of pavement and sidewalk sections.
3. Fill material shall not be placed, spread, or rolled while the material is frozen or thawing, or during unfavorable weather conditions.
4. Moisture condition or dry fill material as required to obtain specified moisture content limits.
   a. Material which is too wet to allow proper compaction, as determined by testing agency, may be spread and permitted to dry assisted by disking, harrowing, or pulverizing.
5. Place fill material using spreading equipment capable of obtaining uniform loose lift thickness.
6. Compact fill material using equipment appropriate to the material being compacted, as determined by testing agency.
7. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed fill area is as specified.

8. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.
9. In excavations where testing agency determines that subgrade material is unacceptable, remove unacceptable material and backfill in accordance with procedures determined by testing agency.
10. Minimize construction traffic, including foot traffic, from pavement finished subgrades in order to prevent unnecessary disturbances of subgrade materials.
    a. If testing agency determines that finished subgrades have been disturbed, remove disturbed areas and replace and recompact to required density as directed by testing agency.
    b. If testing agency determines that rutting has occurred, excavate 6 inches, or other depth as directed by testing agency, of subgrade material and recompact as specified for affected area.
    c. Testing agency shall be present during compaction of material.

B. In cut areas below pavements requiring less than 12 inches of fill to obtain finish subgrade elevations, and a lateral distance of 5 feet outside pavement areas, excavate existing material to a depth of not less than 6 inches below bottom of pavement subbase course.
1. Proof-roll subgrade and repair as required in paragraph 3.8.E below, then scarify to a depth of 6 inches to result in a surface free from ruts, hummocks, and other uneven features which, in the opinion of the testing agency, would prevent uniform compaction by the equipment proposed for use.
    a. Moisture condition subgrade to achieve moisture content specified in this Section.
    b. Compact to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between -2 and +3 percent above optimum moisture content in accordance with ASTM D698.
        1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
        2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
2. After scarifying, moisture conditioning, and recompacting, backfill areas using approved materials placed in loose lifts not exceeding 8 inches.
    a. compact each lift to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between -2 and +3 percent above optimum moisture content in accordance with ASTM D698.
        1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
        2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
3. Protect excavations from excessive wetting and drying during construction.
    a. Remove water entering excavation, and remove disturbed or softened soil.
4. Maintain subgrade moisture content within specified range until pavements are installed.
    a. Rework non-complying area as required to achieve specified requirements as directed by testing agency.
    b. Recompact and retest until required density and moisture content is obtained.

C. In areas below pavements requiring 12 inches or more of fill to obtain finish subgrade elevations, and a lateral distance of 5 feet outside pavement areas, proofroll existing subgrade

in presence of testing agency using a fully loaded tandem axle dump truck or similar type of pneumatic tired equipment with a minimum gross weight of 20 tons.

1. Remove soft areas as directed by testing agency and recompact in loose 9 inch lifts to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between -2 and +3 percent above optimum moisture content in accordance with ASTM D698.
    a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
    b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
2. After proofrolling operations are performed and observed soft areas repaired, place approved material in loose lifts not exceeding 8 inches.
    a. Compact each lift to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between -2 and +3 percent above optimum moisture content in accordance with ASTM D698.
        1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
        2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
3. Fill operations shall continue in compacted layers until finish subgrade elevations have been obtained.
    a. Compact each lift to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between -2 and +3 percent above optimum moisture content in accordance with ASTM D698.
        1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
        2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
4. Protect excavations from excessive wetting and drying during construction.
    a. Remove water entering excavation, and remove disturbed or softened soil.
5. Maintain subgrade moisture content within specified range until pavements are installed.
    a. Rework non-complying area as required to achieve specified requirements as directed by testing agency.
    b. Recompact and retest until required density and moisture content is obtained.

D. Tolerances
    1. Top surface of finish subgrade under paved areas: Plus or minus ¼ inch from required elevations.

E. Immediately prior to placement of pavement subbase course and pavements, proofroll subgrade in presence of testing agency using a fully loaded tandem axle dump truck or similar type of pneumatic tired equipment with a minimum gross weight of 20 tons.
    1. Remove soft areas as directed by testing agency and recompact in loose 9 inch lifts to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between -2 and +3 percent above optimum moisture content in accordance with ASTM D698.

a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

3.09 GENERAL SITE FILL

A. General:
1. Testing agency shall be present during placement and compaction of fill material.
2. Fill material shall not be placed, spread, or rolled while the material is frozen of thawing, or during unfavorable weather conditions.
3. Moisture condition or dry fill material as required to obtain specified moisture limits.
4. Material which is too wet to allow proper compaction, as determined by testing agency, may be spread and permitted to dry assisted by dishing, harrowing, or pulverizing.
5. Place fill material using spreading equipment capable of obtaining uniform loose lift thickness.
6. Compact fill material using equipment appropriate to the material being compacted, as determined by testing agency.
7. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed fill area is as specified.
8. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.

B. Perform grading to the contours and elevations indicated on Drawings:
1. Uniformly grade areas to a smooth surface, free from irregular surface changes.
2. Provide a smooth transition between existing adjacent grades and new grades.

C. Place general fill material in systematic and uniform horizontal lifts not exceeding the following loose-depth-measurements:
1. For fill material to be compacted with heavy compaction equipment: 9 inches.
2. For fill material to be compacted with hand operated tampers: 4 inches.

D. Under sidewalks and ramps compact each lift of material to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between -2 and +3 percent above optimum moisture content in accordance with ASTM D698
1. In other areas, compact each lift of material to a minimum of 90 percent of the material's maximum Standard Proctor dry density with a moisture content between -2 and +3 percent above optimum moisture content in accordance with ASTM D698
a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework on-complying area as required to achieve specified requirements.

E. Bench existing slopes horizontal sections equal in width to equipment used.

F. Where embankments, regardless of height, are placed against hillsides or existing embankments having a slope of steeper than 1 vertical to 5 horizontal, bench or step existing slope in approximately 24 inch rises:
1. Place fill in lifts not exceeding 9 inches in loose-depth-measurement
2. Compact material bladed out, bottom area which was cut to form benches, and fill material being placed, to a minimum of 95 percent of the material's maximum Standard

Proctor dry density with a moisture content between -2 and +3 percent above optimum moisture content in accordance with ASTM D698.

a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

G. Remove surplus materials from Site, at no increase in Contract Sum or extension of Contract Time.
1. Submit an acceptable agreement with the property owner on whose property the material is placed.

H. Tolerances:
1. Top surface of finish subgrade under paved areas: Plus or minus ¼ inch from required elevations.
2. Top surface of finish subgrade under unpaved surfaces: Plus or minus ½ inch from required elevations.

3.10 INSTALLATION OF GRANULAR FILL

A. Immediately prior to placement floor slab granular base, testing agency will evaluate subgrade to determine whether moisture content is within specified range, and whether subgrade has been disturbed.
1. In areas where testing agency determines subgrade is not within specified moisture content range, remove non-complying areas and replace and recompact to required density, within specified moisture content range, as directed by testing agency.
a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
b. When test indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
2. If testing agency determines that rutting has occurred or other detrimental conditions exist, excavate 6 inches, or other depth as directed by testing agency, of subgrade material and recompact as specified for affected area.
a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

B. Place granular fill in equal continuous layers not exceeding 6 inches.
1. Compact granular fill using heavy vibrating equipment, in 3 passes, to achieve a total compacted thickness of 4 inches in presence of Owner's representative or testing agency.
2. Compact granular fill in confined areas using a combination of manually operated vibratory plates and "wacker" compaction equipment.

C. Tolerances:
1. Top surface of finish subgrade under slabs-on-grade: Plus or minus ¼ inch from required elevations.

3.11 INSTALLATION OF PAVEMENT SUBBASE COURSE

A. Place pavement subbase course in equal continuous layers not exceeding 6 inches.
   1. Compact granular fill for pavement and sidewalk subbase course to a minimum of 95 percent of the material's maximum standard proctor dry density in accordance with ASTM D698.
   2. Compact granular fill in confined areas using a combination of manually operated vibratory plates and "wacker" compaction equipment.
   3. Qualitative tests shall be taken after the compaction of each layer of fill by testing agency.

B. Tolerances:
   1. Top surface of finish subgrade under paved areas: Plus or minus ¼ inch from required elevations.

3.12 BEDDING

A. Place and compact bedding course on trench bottoms and where indicated on Drawings.
   1. Install materials in continuous layers not exceeding 6 inches compacted depth.

B. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Install bedding to a depth of 6 inches below bottom of pipe bell or conduit, to an elevation of 6 inches above pipe or conduit.

D. Compact bedding materials by slicing with a shovel and compacting with vibratory plates and "wacker" compaction equipment.

E. Support pipe and conduit during placement and compaction of bedding fill.

3.13 INSTALLATION OF BACKFILL

A. Backfill excavations promptly, but not before completion of the following:
   1. Surveying location of underground utilities for Record Documents
   2. Testing, inspecting, and approval of underground utilities
   3. Removal of concrete forms
   4. Removal of lumber, rock, paper, and other debris from areas to be backfilled
   5. Removal of temporary shoring, bracing, and sheeting

B. Backfill areas to contours and elevations indicated on Drawings, using unfrozen backfill material
   1. Do not backfill over porous, wet, frozen, thawing, or spongy surfaces
   2. Do not backfill during unfavorable weather conditions
   3. Moisture condition or dry backfill material as required to obtain specified moisture content limits
      a. Material which is too wet to allow proper compaction, as determined by testing agency
   4. Place backfill material using equipment capable of obtaining uniform loose lift thickness
   5. Compact backfill material using equipment appropriate to the material being compacted, as determined by testing agency
   6. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously laced backfill areas is as specified
   7. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.
   8. Compaction in lawn and planter areas is 85% maximum.

C. Backfilling of curbs, slabs-on-grade, and other structures whose foundation is unprotected from water shall be accomplished as soon as forms are removed, to eliminate possibility of softening of subbase below structure

D. Backfill foundation walls with granular material, not less than 24 inches in width, to an elevation of 2 feet below finish grade.
   1. Backfill simultaneously on each side of unsupported foundation walls.
   2. Backfill upper 2 feet using General Fill Material.

E. Backfill trenches to contours and elevations indicated on Drawings, using unfrozen backfill material.
   1. Do not backfill over porous, wet, frozen, or spongy surfaces.
   2. Do not backfill during unfavorable weather conditions.
   3. Moisture condition or dry backfill material as required to obtain specified moisture content limits.
      a. Material which is too wet to allow proper compaction, as determined by testing agency, may be spread and permitted to dry assisted by disking, harrowing, or pulverizing.
   4. Place backfill material using equipment capable of obtaining uniform loose lift thickness.
      a. Employ a placement method of backfill operations which does not disturb or damage utilities in trenches.

F. Backfill trenches that carry below or pass under footings and that are excavated within 18 inches of footings with concrete.
   1. Place concrete to elevation equal to bottom of footings.

G. Compaction of General Backfill
   1. Maintain optimum moisture content of backfill materials to attain required compaction density.
   2. General Fill Materials used for backfill shall be placed in lifts not exceeding 9 inches in loose-depth-measure and compacted as specified for General Site Fill
   3. Granular Fill Materials used for backfill shall be placed in lifts not exceeding6 inches in loose-depth-measure and compacted as specified for Granular Fill.
   4. Field density tests shall be taken after the compaction of each layer of backfill by testing agency.
      a. When tests indicate that any layer of backfill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

H. Compaction of Trench Backfill
   1. Compact backfill material using equipment appropriate to the material being compacted, as determined by testing agency.
   2. Maintain optimum moisture content of backfill materials to attain required compaction density.
   3. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed backfill area is as specified.
   4. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.
   5. General Fill Material used for backfill shall be placed in lifts not exceeding 4 inches in loose-depth-measure with each lift compacted as specified in this section.
   6. MoDOT Standard Specification for Highway Construction Type 5 aggregate used for backfill shall be placed in lifts not exceeding 6 inches in loose-depth-measure and compacted to a minimum of 97 percent of the material's maximum Standard Proctor dry density with a moisture content near optimum in accordance with ASTM D698.

7. Field density tests shall be taken after the completion of each layer of backfill by testing agency.
    a. When tests indicate that any layer of backfill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

I. Slope grade away from building not less than 12 inches in 10 foot for a distance of not less than 6 feet outside of building lines.
1. Make grade changes gradual.
2. Blend slopes into level areas.
3. Remove surplus materials from Site, at no increase in Contract Sum or extension of Contract Time
4. Submit an acceptable agreement with the property owner on whose property the material is placed

J. Tolerances:
1. Top surface of finish subgrade under paved areas: Plus or minus ¼ inch from required elevations
2. Top surface of finish subgrade under unpaved areas. Plus or minus ½ inch from required elevations

3.14 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Geotechnical Engineer.

D. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 6938, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft. or less of paved area or building slab, but in no case fewer than three tests.
2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet or less of wall length, but no fewer than two tests.
3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length, but no fewer than two tests.

E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.15 PROTECTION

A. Protect newly graded areas from freezing and erosion.

B. Repair and reestablish grades in settled, eroded, and rutted areas to specified tolerances.

C. Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape, and compact to required density prior to further construction.
   1. Testing agency shall be present during compaction of material.

END OF SECTION

SECTION 312319
DEWATERING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes construction dewatering.

B. Related Sections include the following:
   1. "Earth Moving" for excavating, backfilling, site grading and for site utilities.

1.03 PERFORMANCE REQUIREMENTS

A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control ground-water flow into excavations and permit construction to proceed on dry, stable subgrades.
   1. Maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, that excavation does not flood, and that damage to subgrades and permanent structures is prevented.
   2. Prevent surface water from entering excavations by grading, dikes, or other means.
   3. Accomplish dewatering without damaging existing buildings adjacent to excavation.
   4. Remove dewatering system if no longer needed.

1.04 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with water disposal requirements of authorities having jurisdiction.

B. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination."

1.05 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Design Professional and then only after arranging to provide temporary utility services according to requirements indicated.

B. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. Owner will not be responsible for interpretations or conclusions drawn from this data.
   1. Make additional test borings and conduct other exploratory operations necessary for dewatering.
   2. The geotechnical report is included elsewhere in the Project Manual.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.
   1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site and surrounding area.
   2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
   1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

3.02 INSTALLATION

A. Provide an adequate system to lower and control ground water to permit excavation, and placement of fill materials on dry subgrades.
   1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.

B. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water in a manner that avoids inconvenience to others. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.

C. Provide standby equipment on-site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense to Owner.
   1. Damages: Promptly repair damages to adjacent facilities caused by dewatering operations.

END OF SECTION

SECTION 321313
CONCRETE PAVING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Driveways.
   2. Roadways.
   3. Parking lots.
   4. Curbs and gutters.
   5. Walks.

B. Work in public right-of-way: All work in public right-of-way shall be performed per City Standards and Specifications.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For each exposed product and for each color and texture specified.

C. Other Action Submittals:
   1. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
   2. Aggregates: Aggregates must be supplied from a source previously tested and certified by MoDOT as meeting "Aggregates for Concrete" requirements in Section 1005 of MoDOT Standard Specifications. Aggregate shall be sound and durable and meet ASTM C586.

1.03 QUALITY ASSURANCE

A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

B. ACI Publications: Comply with ACI 301 (ACI 301M) unless otherwise indicated.

PART 2 PRODUCTS

2.01 STEEL REINFORCEMENT

A. Epoxy-Coated Welded-Wire Reinforcement: ASTM A 884/A 884M, Class A, plain steel.

B. Epoxy-Coated Reinforcing Bars: ASTM A 775/A 775M or ASTM A 934/A 934M; with ASTM A 615/A 615M, Grade 60 (Grade 420) deformed bars.

C. Epoxy-Coated-Steel Wire: ASTM A 884/A 884M, Class A; coated, deformed.

D. Epoxy-Coated, Joint Dowel Bars: ASTM A 775/A 775M; with ASTM A 615/A 615M, Grade 60 (Grade 420) plain-steel bars.

E. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified.

2.02 CONCRETE MATERIALS AND MIXTURES

A. Portland cement concrete shall conform to MoDOT 501 and 1005 with the following modifications:
   1. All portland cement concrete shall be air entrained with 6% (± 1%) minimum air content.
   2. The use of calcium chloride is not permitted.
   3. The allowable slump shall be not more than 4 inches.
   4. The minimum 28-day compressive strength shall be 4,000-psi.
   5. Aggregate:
      a. The combined maximum weight of flint and chert shall be 1% of the weight of coarse aggregate.
      b. The maximum weight of lignite shall be 0.07% of the weight of the fine aggregate.

2.03 CURING MATERIALS

A. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.

2.04 RELATED MATERIALS

A. Joint Fillers: ASTM D 1751, asphalt-saturated cellulosic fiber.

2.05 WHEEL STOPS

A. Wheel Stops: Precast, air-entrained concrete.
   1. Dowels: Galvanized steel, 3/4 inch (19 mm) in diameter, 10-inch (254-mm) minimum length.
   2. Adhesive: As recommended by wheel stop manufacturer for application to concrete pavement.

PART 3 EXECUTION

3.01 EXAMINATION AND PREPARATION

A. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.

B. Remove loose material from compacted subbase surface immediately before placing concrete.

C. Prior to concrete paving, Contractor shall prepare mockup for concrete pavement and sidewalks. Mockup to include a minimum of 100 square feet of paving. Mockup may be installed "in-place" and must demonstrate the proposed joint types, reinforcement, sealant, and saw-cutting. Prepare mockup for Owner review and approval, prior to concrete paving.

3.02 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.03 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

3.04 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, to match jointing of existing adjacent concrete paving.

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch (6-mm) radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.05 CONCRETE PLACEMENT

A. Moisten subbase to provide a uniform dampened condition at time concrete is placed.

B. Comply with ACI 301 (ACI 301M) requirements for measuring, mixing, transporting, placing, and consolidating concrete.

C. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

D. Screed paving surface with a straightedge and strike off.

E. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

3.06 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

1. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.

3.07 COLD AND HOT WEATHER CONCRETE PLACEMENT

A. Cold Weather Concrete:

1. Unless authorized in writing by the Engineer, mixing and concreting operations shall be discontinued when the descending air temperature in the shade and away from artificial heat reaches thirty-five (35°) degrees F. Concrete operations may be resumed when the ascending air temperature in the shade and away from artificial heat reaches thirty five (35°) degrees F.
2. When concrete work is authorized during cold weather, the concrete may be heated in accordance with ACI specifications. The temperature of the concrete shall be not less than sixty (60°) degrees F and not more than eighty (80°) degrees F at the time of placement in the forms.
3. No concrete shall be placed on frozen subgrade. Sudden cooling of concrete shall not be permitted. Concrete exposed to frost action or freezing weather shall be removed and replaced at the Contractor's expense.

4. A sufficient supply of approved blanketing material shall be provided and placed on all concrete placed between November 1 and April 1 and at other times when the ambient air temperature is expected to drop below forty (40°) degrees F. Blanketing materials shall protect the concrete and maintain a minimum temperature of forty (40°) degrees F in the concrete as measured on the surface. Concrete shall be covered for at least four days.

B. Hot Weather Concrete:
1. The provisions of this section shall apply to all concrete work, which is done when the air temperature is above eighty (80°) degrees F at the time of placement. The temperature of the concrete, when placed, shall not be high enough to cause excessive loss of slump, flash set or cold joints. Forms, reinforcing and sub-grade surfaces against which the concrete is to be placed shall be wetted down immediately before placement. In no case shall the temperature of the concrete, when placed, exceed ninety (90°) degrees F.
2. When the air temperature exceeds ninety (90°) degrees F and as soon as practicable without causing damage to the surface finish, all exposed concrete shall be kept continuously moist by means of fog sprays, wet burlap, cotton mats, or other means acceptable to the Engineer at no expense to the Owner. This cooling with water shall be in addition to the initial sealing by membrane curing compound.
3. No concrete shall be placed when the air temperature is above ninety-five (95º) degrees F.

3.08 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by curing compound.

3.09 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 and as follows:
1. Elevation: 1/8 inch (3 mm).
2. Thickness: Plus 3/8 inch (10 mm), minus 1/4 inch (6 mm).
3. Surface: Gap below 10-foot- (3-m-) long, unleveled straightedge not to exceed 1/4 inch (6 mm).
4. Joint Spacing: 3 inches (75 mm).
5. Contraction Joint Depth: Plus 1/4 inch (6 mm), no minus.
6. Joint Width: Plus 1/8 inch (3 mm), no minus.

3.10 WHEEL STOPS

A. Install wheel stops in bed of adhesive applied as recommended by manufacturer.

B. Securely attach wheel stops to paving with not less than two [**galvanized-**]steel dowels located at one-quarter to one-third points. Install dowels in drilled holes in the paving and bond dowels to wheel stop. Recess head of dowel beneath top of wheel stop.

3.11 OPENING TO TRAFFIC

A. The concrete pavement shall not be opened for light traffic until the concrete is at least 72 hours old and has attained a minimum compressive strength of 3000 pounds per square inch. The pavement shall not be opened to all types of traffic until the concrete is at least 72 hours old and has attained a minimum compressive strength of 3500 pounds per square inch. If high early strength concrete is used, the pavement may be opened to all types of traffic when the concrete has attained a minimum compressive strength of 3500 pounds per square inch. Pavement shall be cleaned prior to opening to traffic

3.12 FIELD QUALITY CONTROL

A. Testing Agency: The Owner will engage a qualified independent testing and inspection agency to sample materials, perform tests, and submit test reports during concrete placement according to requirements specified in this Article.

B. Testing Services: Testing shall be performed according to the following requirements:
   1. Sampling Fresh Concrete: Representative samples of fresh concrete shall be obtained according to ASTM C 172, except modified for slump to comply with ASTM C 94.
   2. Slump: ASTM C 143; one test at point of placement for each compressive-strength test, but not less than one test for each day's pour of each type of concrete. Additional tests will be required when concrete consistency changes.
   3. Air Content: ASTM C 231, pressure method; one test for each compressive-strength test, but not less than one test for each day's pour of each type of air-entrained concrete.
   4. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each set of compressive-strength specimens.
   5. Compression Test Specimens: ASTM C 31/C 31M; one set of four standard cylinders for each compressive-strength test, unless otherwise indicated. Cylinders shall be molded and stored for laboratory-cured test specimens unless field-cured test specimens are required.
   6. Compressive-Strength Tests: ASTM C 39; one set for each day's pour of each concrete class exceeding 5 cu. yd., but less than 100 cu. yd., plus one set for each additional 100 cu. yd. One specimen shall be tested at 7 days and two specimens at 28 days; one specimen shall be retained in reserve for later testing if required.
   7. In-place pavement thickness will be determined by test core samples. One core sample will be taken for every 1,000 square yard or less of installed pavement, with no fewer than 3 cores taken.
   8. When frequency of testing will provide fewer than five compressive-strength tests for a given class of concrete, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
   9. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, current operations shall be evaluated and corrective procedures shall be provided for protecting and curing in-place concrete.
   10. Strength level of concrete will be considered satisfactory if averages of sets of three consecutive compressive-strength test results equal or exceed specified compressive strength and no individual compressive-strength test result falls below specified compressive strength by more than 500 psi.

C. Test results shall be reported in writing to Owner, Design Professional, and Contractor within 24 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing agency, concrete type and

class, location of concrete batch in pavement, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

D. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Design Professional but will not be used as the sole basis for approval or rejection.

E. Additional Tests: Testing agency shall make additional tests of the concrete when test results indicate slump, air entrainment, concrete strengths, or other requirements have not been met, as directed by Design Professional. Testing agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed.

3.13 REPAIRS AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Design Professional.

B. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

C. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 321313

SECTION 321373
CONCRETE PAVING JOINT SEALANT

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Cold-applied joint sealants.

B. Related Sections:
   1. Division 32 Section "Concrete Paving" for constructing joints in concrete pavement.

1.02 ACTION SUBMITTALS

A. Product Data: For each joint-sealant product indicated.

B. Samples for Verification: For each kind and color of joint sealant required, provide Samples with joint sealants in 1/2-inch- (13-mm-) wide joints formed between two 6-inch- (150-mm-) long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

C. Pavement-Joint-Sealant Schedule: Include the following information:
   1. Joint-sealant application, joint location, and designation.
   2. Joint-sealant manufacturer and product name.
   3. Joint-sealant formulation.
   4. Joint-sealant color.

1.03 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of joint sealant and accessory, from manufacturer.

B. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for joint sealants.

C. Preconstruction Compatibility and Adhesion Test Reports: From joint-sealant manufacturer, indicating the following:
   1. Materials forming joint substrates and joint-sealant backings have been tested for compatibility with and adhesion to joint sealants.
   2. Interpretation of test results and written recommendations for primers and substrate preparation needed for adhesion.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Source Limitations: Obtain each type of joint sealant from single source from single manufacturer.

C. Product Testing: Test joint sealants using a qualified testing agency.
   1. Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1021 to conduct the testing indicated.

D. Preinstallation Conference: Conduct conference at Project site.

1.05 PROJECT CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:
   1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F (5 deg C)
   2. When joint substrates are wet.

3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 PRODUCTS

2.01 MATERIALS

A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer based on testing and field experience.

B. Colors of Exposed Joint Sealants: As selected by Design Professional from manufacturer's full range color.

2.02 COLD-APPLIED JOINT SEALANTS

A. Multicomponent, Nonsag, Urethane, Elastomeric Joint Sealant: ASTM C920, Type M, Grade NS, Class 25, for Use T.
1. Suggested inexhaustive manufacturers list:
a. Pecora Corporation.
b. Sika Corporation.
c. BASF.

2.03 JOINT-SEALANT BACKER MATERIALS

A. General: Provide joint-sealant backer materials that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by joint-sealant manufacturer based on field experience and laboratory testing.

B. Round Backer Rods for Cold-Applied Joint Sealants: ASTM D 5249, Type 3, of diameter and density required to control joint-sealant depth and prevent bottom-side adhesion of sealant.

2.04 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions.

B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

3.03 INSTALLATION OF JOINT SEALANTS

A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.

B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Install joint-sealant backings of kind indicated to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
   1. Do not leave gaps between ends of joint-sealant backings.
   2. Do not stretch, twist, puncture, or tear joint-sealant backings.
   3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.

D. Install joint sealants using proven techniques that comply with the following and at the same time backings are installed:
   1. Place joint sealants so they directly contact and fully wet joint substrates.
   2. Completely fill recesses in each joint configuration.
   3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

E. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants according to the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:
   1. Remove excess joint sealant from surfaces adjacent to joints.
   2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.

F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

3.04 CLEANING

A. Clean off excess joint sealant or sealant smears adjacent to joints as the Work progresses, by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.05 PROTECTION

A. Protect joint sealants, during and after curing period, from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations in repaired areas are indistinguishable from the original work.

END OF SECTION

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SECTION 323113
CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Polymer-coated steel framework: chain-link fences
   2. Gates: horizontal slide

1.02 SUBMITTALS

A. Product Data: For each product indicated.

B. Shop Drawings: Show locations, components, materials, dimensions, sizes, weights, finishes of components, installation and operational clearances, gate swings, and details of post anchorage and attachment and bracing.

C. Samples: For polymer coating on framing and accessories.

D. Maintenance Data: For polymer finishes.

E. Warranty: sample of special warranty

PART 2 PRODUCTS

2.01 CHAIN-LINK FENCE FABRIC

A. General: Provide fabric in one-piece heights measured between top and bottom of outer edge of selvage knuckle or twist. Comply with CLFMI product Manual and with requirements indicated below:
   1. Fabric Height: 96 inches
   2. Wire Fabric: Wire with a diameter of 0.120 inch.
      a. Mesh Size: 2 inches
      b. Zinc-Coated Fabric: ASTM A 392, Type II Class 1, 1.2 oz/sq. ft. with zinc coating applied after weaving.
   3. Selvage: Knuckled at both selvages.

2.02 FENCE FRAMING

A. Posts and Rails: Comply with ASTM F 1043 for framing, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thickness according to ASTM F 1043 or ASTM F 1083 based on the following:
   1. Fence Height: 96 inches
   2. Light Industrial Strength: Material Group IC-L, round steel pipe, electric-resistance-welded pipe.
      a. Line Post: 2.375 inches
      b. End, Corner and Pull Post: 4.0 inches.
   3. Horizontal Framework Members: Top and bottom rails complying with ASTM F1043.
      a. Top and bottom rail size: 1.625 inches
   4. Brace Rails: Comply with ASTM F 1043.
   5. Metallic Coating for Steel Framing:
      a. Type A zinc coating.

2.03 TENSION WIRE

A. Metallic-Coated Steel Wire: 0.177-inch- (4.5-mm-) diameter, marcelled tension wire complying with ASTM A 817 and ASTM A 824, with the following metallic coating:

1. Type II, zinc coated with minimum coating weight matching chain-link fabric coating weight.

2.04 SWING GATES

A. General: Comply with ASTM F 900 for gate posts and single and double swing gate types.
   1. Gate Leaf Width: 36 inches or as indicated on drawing.
   2. Gate Fabric Height: 96 inches.

B. Pipe and Tubing:
   1. Zinc-Coated Steel: Comply with ASTM F 1043 and ASTM F 1083; protective coating and finish to match fence framing.
   2. Gate Posts: Round tubular steel.
   3. Gate Frames and Bracing: Round tubular steel.

C. Frame Corner Construction: Welded.

D. Hardware:
   1. Hinges: 180-degree outward swing.
   2. Latches permitting operation from both sides of gate with provision for padlocking accessible from both sides of gate.
   3. Padlock and Chain: As required by Owner.
   4. Lock: Manufacturer's standard internal device furnished in lieu of gate latch.
   5. Closer: Manufacturer's standard.

2.05 FITTINGS

A. General: Comply with ASTM F 626.

B. Finish:
   1. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 oz. /sq. ft. zinc.

2.06 CAST-IN-PLACE CONCRETE

A. General: Comply with ACI 301 for cast-in-place concrete; materials consisting of portland cement complying with ASTM C 150, aggregates complying with ASTM C 33, and potable water.
   1. Concrete Mixes: Normal-weight concrete air entrained with not less than 3000-psi (20.7-MPa) compressive strength (28 days), 3-inch (75-mm) slump, and 1-inch (25-mm) maximum size aggregate.

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Install chain-link fencing to comply with ASTM F 567 and more stringent requirements indicated. Do not begin installation before final grading is completed, unless otherwise permitted by Engineer.

B. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed or compacted soil.

C. Post Setting: Hand-excavate holes for post foundations in firm, undisturbed or compacted soil.
   1. Concrete Footings: Place concrete around posts and vibrate or tamp for consolidation. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during placement and finishing operations until concrete is sufficiently cured. Set the following post types in concrete footings and protect portion of posts aboveground from concrete splatter:
      a. Terminal.

b. Line; Using mechanical devices to set line posts per ASTM F 567 is not permitted.
c. Gate.
d. Gate operator-mounting.

D. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment s as indicated on drawings.

E. Line Posts: Space line posts uniformly at 10 feet o.c.

F. Intermediate Rails: Install in one piece, spanning between posts, using fittings, special offset fittings, and accessories.

G. Bottom Rails: Install, spanning between posts, using fittings and accessories.

H. Chain-Link Fabric: Apply fabric to outside of enclosing framework.

I. Tie Wires: Attach wire to chain-link fabric per ASTM F 626. Tie fabric to line posts at maximum interval of 12 inches (304 mm) o.c. and to braces at maximum interval of 24 inches (609 mm) o.c.

J. Gate Installation: Install gates level, plumb, and secure for full opening without interference. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust gate to operate smoothly, easily, and quietly throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

END OF SECTION

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SECTION 329119
LANDSCAPE GRADING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Final grade topsoil for finish landscaping.

B. Related Sections:
   1. Section 311000 – Site Clearing.
   2. Section 312000 – Earth Moving.

1.02 SUBMITTALS

A. Product Data: Manufacturer's specifications and technical data on soil stabilizers.

B. Certifications: Submit statement certifying location of property from which imported topsoil is proposed to be obtained:
   1. Include names and addresses of property owners, depth of topsoil to be stripped, and crops grown during last 2 years.

1.03 QUALITY ASSURANCE

A. Installer's Qualifications: Firm experienced in installation of systems similar in complexity to those required for this Project.

PART 2 PRODUCTS

2.01 MATERIALS

A. Contractor shall install a minimum of 4 inches of topsoil on all disturbed areas. Contractor may use a combination of acceptable stockpiled topsoil and/or imported topsoil.

B. Stockpiled Topsoil: ASTM D5268, fertile, friable, natural silty clay loam, surface soil, reasonably free (less than 5 percent of total volume) of subsoil, clay lumps, brush, weeds, and other litter, and free of roots, stumps, stones larger than 3/8 inch, in any dimension, and other extraneous or toxic matter harmful to plant growth, approved by Owner's testing agency.
   1. Acidity range (ph): 5.5 and 7.5.
   2. Organic matter content: 4 to 25 percent.
   3. Remove particles larger than 3/8 inch in size.
   4. Process, clean, and prepare existing topsoil to comply with above specified criteria.

C. Imported Topsoil: ASTM D5268, fertile, friable, natural silty clay loam, surface soil, reasonably free (less than 5 percent of total volume) of subsoil, clay lumps, brush, weeds, and other litter, and free of roots, stumps, stones larger than 3/8 inch, in any dimension, and other extraneous or toxic matter harmful to plant growth, approved by Owner's testing agency.
   1. Acidity range (ph): 5.5 and 7.5.
   2. Organic matter content: 4 to 25 percent.
   3. Obtain topsoil from local sources or from areas having similar soil characteristics to that found at Project Site.
      a. Obtain topsoil from naturally, well-drained sites, where topsoil occurs in a depth of not less than 4 inches.
         1) Do not obtain from bogs or marshes.
      b. Designate proposed topsoil borrow area and provide verification by a testing agency that the soil in the area meets imported topsoil criteria.
   4. Remove particles larger than 3/8 inch in size.
   5. Process, clean, and prepare imported topsoil to comply with specified criteria.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper and timely completion.
   1. Do not proceed until unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Protection:
   1. Protect trees, shrubs, lawns, other plant growth, and other features indicated on Drawings to remain.
   2. Protect bench marks, monuments, existing structures, existing fences, existing roads, existing sidewalks, existing paving, and existing curbs from damage and displacement.

B. Preparation:
   1. Use all means necessary to control dust on and near Work if such dust is caused by performance of the work of this Section, of it resulting from the condition in which Project Site is left by Contractor.
   2. Moisten surfaces as required to prevent dust from being a nuisance to the public, neighbors, and concurrent performance of other Work on Project Site.
   3. Identify required lines, levels, contours, and datum.
   4. Identify above and below grade utilities.
   5. Provide and maintain positive surface drainage.
   6. Loosen subgrade not less than 4 inches.
   7. Remove stones measuring over 3/8 inch in any dimension.
   8. Remove sticks, rubbish, and other extraneous matter.

3.03 INSTALLATION

A. Grade Project Site to uniform slopes between points for which finish grades are indicated on Drawings, or between such points and existing established grades.
   1. Provide vertical curves or roundings at abrupt changes in slopes.
   2. Grade using topsoil which is relatively dry.
   3. Grade during dry weather.

B. Remove stone, roots, grass, weeds, debris and foreign matter larger than 3/8 inch in size from topsoil.

C. Fine grade topsoil to eliminate rough or low area.

D. Manually spread topsoil around trees, building, and paving to prevent damage.

E. Roll placed topsoil.
   1. Total thickness of topsoil after compaction shall be not less than 6 inches.
   2. Import topsoil as required to achieve required total compacted thickness.

F. If surplus topsoil occurs, deposit on Site at area designated by Owner's Representative.

G. Tolerances: Top of topsoil: Plus or minus 0.10 foot from grades indicated on Drawings.

END OF SECTION

SECTION 329219
SEEDING

PART 1 GENERAL

1.01 WORK INCLUDED

A. This section covers furnishing and sowing seed, compacting, mulching, and establishing turf in accordance with this specification at the locations shown on the drawings.

B. Furnish all labor, tools, equipment, material, and perform all operations necessary and incidental to proper execution and completion of all work in accordance with the drawings and specifications.

C. Contractor shall seed all disturbed areas.

PART 2 PRODUCTS

2.01 SEED

A. All seed shall be furnished in sealed containers. Seed that has become wet, moldy, or otherwise damaged in transit or storage will not be acceptable. The seed mixture shall be as follows: Submit all seed certificates to the Owner's Representative.

2.02 SEED MIXTURES

A. Hybrid Fescue Mix "Rebel II" or "Falcon"
   1. Hybrid Fine Fescue:
      a. Minimum % Pure Live Seed: 95%
      b. % Germ.: 85%
      c. Rate of application per 1000 square feet area: 7 pounds
   2. Kentucky Bluegrass
      a. Minimum % Pure Live Seed: 80%
      b. % Germ.: 70%
      c. Rate of application per 1000 square feet area: 1 pound.

2.03 MULCH

A. Straw mulch shall be the thrashed plant residue of oats, wheat, barley, or rye from which grain has been removed or optional wood cellulose fiber applied by the hydro-mulching method. The straw shall be free of prohibitive weed seeds as stated in the Missouri Seed Law, and shall be relatively free of all other obnoxious and undesirable seeds.

B. Commercial grade wood cellulose fiber. Nominal moisture content not exceeding 12 percent.

2.04 SOIL FOR REPAIRS

A. Soil for filling areas to be repaired shall be topsoil free of large stones, clods, roots, stumps, or other materials that would interfere with subsequent seeding, compacting, or establishment.

PART 3 EXECUTION

3.01 GENERAL

A. Areas to be seeded are all areas disturbed by construction not covered by pavement, structures or landscape.

B. Soil preparation, applying fertilizer, finish grading, removal of weed growth, and all other operations necessary to prepare the seed bed prior to sowing seed is covered in section FINE GRADING AND FERTILIZING. The seed bed must be in a loose, fine, well-aggregated condition and approved by the owner's representative prior to seeding.

C. Skipped areas wider than the distance between drills, in case of drilling operations or areas averaging more than four (4) inches in width in the case of broadcasting operations shall be reseeded. Drill sowing is the preferred method.

3.02 SOWING SEED

A. All sowing of seed shall be completed between the dates of March 15 and May 30 for spring seeding; and August 15 and October 1 for fall seeding. Sowing delayed beyond the specified dates, and due to circumstances beyond the contractor's control, may be continued upon written approval.

B. The sowing may be stopped when satisfactory results are not likely to be obtained due to drought conditions, excessive moisture, high wind or other unfavorable conditions. Sowing of seed shall be resumed only when conditions are again favorable or when alternative or corrective measures and approved procedures have been adopted.

C. Broadcast Sowing: Seed shall be broadcast by approved sowing equipment where drill sowing is not practical, at a rate which will provide not less than the minimum quantity of seed stated in these specifications. The seed shall be uniformly distributed over the designated areas. Broadcast sowing shall not be done when the wind exceeds a velocity of five (5) miles per hour. The seed shall be placed ¼" to ⅜" in the soil by means of a harrow or cultipacker.

3.03 HYDROSEEDING

A. Mix specified seed, fertilizer and wood cellulose fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogenous slurry suitable for hydraulic.
   1. Use of 45 pounds of wood cellulose fiber mulch per 1,000 square feet of area.

B. Apply slurry uniformly to all areas to be seeded. Rate of application as required to obtain specified seed sowing rate.

C. Use 4' x 8' sheets of plywood or other suitable device along all pavement edges, structures, and fences and around plants to prevent over-spray of mulch onto these surfaces.

3.04 COMPACTING

A. Not applicable if hydroseeding.

B. Immediately after the sowing operations have been completed, the entire area shall be compacted by means of a cultipacker, roller or other approved equipment, in order to reduce air pockets to a minimum. When a cultipacker, or other approved equipment that leaves a roughened surface is used, the final rolling shall be along the contour and at right angles to the prevailing winds to reduce dust. If the mulching operation can be accomplished the same working day the area is seeded, compacting the seed and anchoring the mulch may be done at the same time.

3.05 MULCHING

A. Not applicable if hydroseeding.

B. Straw mulch shall be spread uniformly in a continuous blanket, using not less than 2,000 lb. Per acre or one (1) bale per 1,000 square feet, approximately 4 to 5 straws deep and having soil show through mulch. Mulching shall start at the windward side of relatively flat areas, or at the upper part of a steep slope, and shall continue until the area is completely covered.

C. Immediately following spreading of the straw, the material shall be anchored to the soil by a V-type wheel land packer, a disc harrow set to cut only slightly, or other suitable equipment which will secure the straw firmly in the ground to form a soft binding mulch and prevent loss or bunching by the wind.

3.06 MAINTENANCE

A. Begin maintenance of new turf areas immediately after each area is planted and continue until accepted as specified.

B. Maintain turf by watering, fertilizing, weeding, rolling, regrading and replanting as required to establish a smooth, acceptable turf, free of eroded or bare areas.

C. Remulch with new mulch in areas where mulch has been disturbed by wind or maintenance operations sufficiently to nullify its purpose. Anchor as required to prevent displacement.

D. Replant bare areas with same materials as originally specified.

E. Watering: Watering of seeded areas for germination and establishment is not required. However, the Contractor shall unconditionally guarantee an acceptable stand of grass in all seeded areas. If the Contractor elects to water, provide and maintain temporary piping, hoses, watering equipment, and vehicles as required to convey water and to keep turf areas uniformly moist as required for proper growth and acceptability.

F. Program watering schedule to prevent puddling, water erosion and displacement of seed or mulch.

3.07 MAINTENANCE FERTILIZING

A. 6 to 8 weeks after the original seeding and prior to the first mowing, the Contractor shall apply maintenance fertilizer. Analysis shall be as recommended by the soil test.

3.08 REPAIRS OF SEEDED AREAS

A. When the surface has become gullied or otherwise damaged during the period of establishing turf, the affected area shall be repaired to reestablish the grade and the condition of the soil, and shall be reseeded at the original seed rate. Fill material shall be placed and compacted in six (6) inch lifts. Reseeding shall be done in a manner that will cause a minimum of disturbance to the existing stand of grass.

3.09 ACCEPTANCE

A. When work is completed and seeded areas are in an acceptable condition as specified herein, Owner will, upon request, make an inspection to verify acceptability.
   1. Immediately prior to an inspection, Contractor shall mow the area to be inspected for acceptance. The Owner will do mowing for maintenance.

B. Replant rejected work and continue specified maintenance until reinspected by Owner and found acceptable.

C. Seeded areas will be acceptable provided a uniform stand of specified grass is established that is reasonably free of weeds, bare spots, and surface irregularities, as determined by the Owner and is at least 2 inches tall.

3.10 CLEANUP

A. Promptly remove soil and debris created by seeding work from paved areas and overspreads of hydroseeding mulch from pavement, fences and structures. During the progress of the work, clean wheels of vehicles before leaving site to avoid tracking soil onto surface of roads, walks, or other paved areas.

END OF SECTION

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SECTION 333100
SANITARY UTILITY SEWERAGE PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Sanitary sewage piping.
   2. Manholes.
   3. Connection of building sanitary drainage system to municipal sewers.
   4. Related accessories.

B. Related Sections:
   1. Section 312000 – Earth Moving.

1.02 SUBMITTALS

A. Product Data: Manufacturer's specifications and technical data on the following:
   1. Piping.
   2. Fittings.
   3. Cleanouts.

B. Shop Drawings: Indicate dimensions, description of materials, general construction, specific modifications, component connections, anchorage methods, and installation procedures, plus the following specific requirements.
   1. Include manholes, frames, and covers.

C. Contract Closeout Submittals:
   1. Project Record Documents.
      a. Contractor to provide as-built survey, prepared by Registered Land Surveyor, that indicates the exact location, top elevations, flow lines and pipe sizes of all structures.

1.03 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Not less than 5 years experience in the actual production of specified products.

B. Installer's Qualifications: Firm experienced in installation of systems similar in complexity to those required for this Project, plus the following:
   1. Not less than 3 years experience with systems.
   2. Successfully completed not less than 5 comparable scale projects using this system.

C. Regulatory Requirements:
   1. Comply with requirements of American Public Works Association.
   2. Comply with requirements of City.

D. Certificates: Certification from precast manufacturer that Con^{mic}Shield® with CONTINT was used in the fabrication of sewer manhole.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Deliver products in original unopened packaging with legible manufacturer's identification.

B. Precast concrete sections shall not be delivered to the job until the concrete control cylinders have attained a strength of at least 80 percent of the specified minimum.

C. Precast concrete sections shall be handled carefully and shall not be bumped or dropped. Hooks shall not be permitted to come in contact with joint sections.

D. Precast concrete sections shall be inspected when delivered. All cracked or otherwise visibly defective units will be rejected. City reserves the right to inspect the production of the units at the manufacturing plant.

E. Storage and Protection: Comply with manufacturer's recommendations.

PART 2 PRODUCTS

2.01 MATERIALS

A. Polyvinyl Chloride (PVC) Pipe and Fittings: ASTM D3034, SDR 21.
   1. Joints: Pipe and fittings shall have elastomeric gasket joints providing a watertight seal when tested in accordance with ASTM D3212. Gaskets shall conform to ASTM F477. Solvent welded joints shall not be permitted.

B. Concrete:
   1. Portland Cement Design Mix: 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio.
      a. Reinforcing Fabric: ASTM A 1064/A 1064M, steel, welded wire fabric, plain.
      b. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420-MPa) deformed steel.
   2. Con^{mic}Shield® with CONTINT shall be added to all precast and cast-in-place manholes in accordance with the manufacturer's recommendations.
      a. Cast-in-place concrete invert fill and collars inside the manhole shall contain Con^{mic}Shield® with CONTINT per manufacturer's recommendation.

2.02 COMPONENTS

A. Manholes: ASTM C478, precast reinforced concrete.
   1. Base section:
      a. Floor slab: 8 inch thick, unless otherwise indicated on drawings.
      b. Walls: 6 inch thick, unless otherwise indicated on drawings.
      c. Base riser section: 6 inch thick, unless otherwise indicated on drawings.
   2. Riser section: 48 inch diameter unless otherwise indicated on Drawings, with 6 inch thick walls.
   3. Top section: Concentric cone, eccentric cone, or flat slab type, as indicated on Drawings.
      a. Top of cone to match grad rings.
   4. Grade rings: Reinforced concrete rings, 4 to 9 inches thick.
   5. Gasket: O-ring, double ring, or preformed bitumastic sealant.
   6. Steps: Steel reinforced polypropylene plastic steps per ASTM 4101, cast into base, riser and top sections at 12 inch intervals.
   7. Frame and cover: ASTM A48, Class 35B gray iron.
      a. Frame size: 24 inch inside diameter, by 9 inch riser with 4 inch width flange.
      b. Cover: 26 inch diameter, indented top design, with lettering "SANITARY SEWER" cast into cover.
   8. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
   9. Pipe connectors: ASTM C923, resilient type.
      a. Provide "boot" type nitrile rubber connections at locations indicated on Drawings.
   10. Con^{mic}Shield® with CONTINT shall be added to all precast manholes in accordance with the manufacturer's recommendations.
      a. Cast-in-place concrete invert fill and collars inside the manhole shall contain Con^{mic}Shield® with CONTINT per manufacturer's recommendation.

2.03 ACCESSORIES

A. Cleanouts: Cast-iron ferrule and countersunk brass cleanout plug, with round cast-iron access frame and heavy-duty, secured, scoriated cast-iron cover.

B. Underground Warning Tape: Polyethylene plastic tape with magnetic detectable conductor, 6 inches wide by 4 mils thick.
   1. Imprint warning tape with “CAUTION – SEWER SERVICE LINE BURIED BELOW” in large black letters.

C. Bedding Materials: As specified under Section 312000.

D. Fill Materials: As specified under Section 312000.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper and timely completion.
   1. Do not proceed until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Trenching: Comply with requirements of Section 312000.
   1. Grade trench bottom to provide smooth, firm, stable, and rock free foundation throughout length of pipe.
   2. Remove unstable, soft, and unsuitable materials from surface upon which pipe is to lay.
      a. Backfill with bedding materials.
   3. Shape bottom of trench to fit design of pipe.
      a. Fill unevenness with tamped bedding materials.
      b. Dig bell holes at each pipe joint to assure continuous bearing of pipe.

B. Install bedding material at trench bottom in accordance with Section 312000.
   1. Install bedding materials in continuous layers not exceeding 6 inches in compacted depth, to total depths indicated on Drawings.
   2. Compact bedding materials as specified under Section 312000.

C. Pipe Installation: Comply pipe manufacturer’s instructions.
   1. Install pipe beginning at low point of system, true to grades and alignment indicated on Drawings and unbroken continuity of invert.
   2. Install PVC pipe in accordance with ASTM D2855 and ASTM F447.
   3. Place bell ends or groove ends of piping facing upstream.
   4. Install gaskets in accordance with manufacturer’s instructions.
   5. Install bedding at sides and over top of pipe to minimum compacted thickness of 12 inches.
   6. Clean interior of piping as Work progresses.
   7. Maintain swab or drag line and pull past each joint as it is completed.
   8. Install plugs in ends of incomplete piping at end of each day and whenever Work stops.

D. Install manholes complete with accessories indicated on Drawings.
   1. Comply with ASTM C891.
   2. Form continuous concrete channel and benches between inlets and outlets.
   3. Install top of frames and covers flush with adjacent paved surfaces.
      a. Install top of frame 3 inches above adjacent landscaped surfaces.

E. Install clean-outs and extension from sewer pipe to clean-out at grade at locations indicated on Drawings.
   1. Set cleanout frame and cover in concrete pad, 18 inches by 18 inches by 12 inches deep, except at where location is in concrete paving.
   2. Set top of cleanout 1 inch above surrounding grade.
   3. Set top of cleanout flush with surrounding pavement.

F. Tap Connections:
   1. Make connections to existing sanitary sewer and underground to comply with requirements of this Section, as indicated on Drawings.

G. Install underground warning tape continuous buried 6 inches below finish grade, above pipe line.
   1. Coordinate with Section 312000.

H. Backfilling: Comply with requirements of Section 312000.

3.03 CLEANING

A. Flush piping between manholes and other structures if required by authority having jurisdiction.
   1. Remove collected debris.

3.04 FIELD QUALITY CONTROL

A. Tests:
   1. Perform testing of completed system in accordance with local authorities having jurisdiction.
   2. Perform the following tests in accordance with APWA Street Construction and Material Specifications, Division II, Section 2509.
      a. Infiltration-exfiltration air test.
      b. Deflection test.

B. Inspections:
   1. Perform inspections in accordance with APWA Street Construction and Material Specifications, Division II, Section 2509.
   2. Inspect interior of piping to determine whether line displacement or other damage has occurred.
   3. Make inspections after pipe between manholes and manhole locations has been installed and approximately 2 feet of backfill material in place.
      a. Reinspect at completion of Project.
   4. If inspections indicate poor alignment, debris, displaced pipe, infiltration, or other defects, correct such defects and reinspect.
      a. Defects requiring correction include the following:
         1) Alignment: Less than full diameter of inside of pipe is visible between structures.
         2) Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
         3) Crushed, broken, cracked, or otherwise damaged piping.
         4) Infiltration: Water leakage into piping.
         5) Exfiltration: Water leakage from or around piping.

C. Video Inspections:
   1. Provide CCTV video footage of sanitary sewer lines to owner prior to substantial completion and acceptance by owner.

3.05 PROTECTION

A. Protect installed sewage system from damage and/or displacement until backfilling operation is complete.

END OF SECTION

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SECTION 334100
STORM UTILITY DRAINAGE PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Storm sewage piping.
   2. Junction boxes.
   3. Inlets.
   4. Yard drains.
   5. Related accessories.

B. Related Sections:
   1. Section 033000 – Cast-In-Place Concrete.
   2. Section 312000 – Earth Moving.
   3. Section 312316 – Excavation.
   4. Section 334613 – Foundation Drainage.

1.2 SUBMITTALS

A. Submit in accordance with Division 1 unless otherwise indicated.

B. Product Data: Manufacturer's specifications and technical data on the following:
   1. Piping.
   2. Fittings.
   3. Yard Drains.
   4. Cleanouts.

C. Shop Drawings: Indicate dimensions, description of materials, general construction, specific modifications, component connections, and installation procedures, plus the following specific requirements:
   1. Include junction boxes, inlets, frames, covers, and grates.

D. Contract Closeout Submittals: Submit in accordance with Division 1.
   1. Project Record Documents.
      a. Accurately record location of underground utilities, by horizontal dimensions from above grade permanent fixtures, elevations or inverts, and slope gradients.

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Not less than 5 years experience in the actual production of specified products.

B. Installer's Qualifications: Firm experienced in installation of systems similar in complexity to those required for this Project, plus the following:
   1. Not less than 3 years experience with systems.
   2. Successfully completed not less than 5 comparable scale projects using this system.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Deliver products in original unopened packaging with legible manufacturer's identification.

B. Storage and Protection: Comply with manufacturer's recommendations.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Reinforced Concrete Pipe: ASTM C76, Class III.
   1. Fittings: Same strength of adjoining pipe.
   2. Joints:
      a. Gaskets: Contractor has option of the following:
         1) ASTM C443, flat gaskets cemented to pipe tongue or spigot.
         2) ASTM C443 O-ring gaskets.
         3) ASTM C443 roll-on gaskets.

B. Polyvinyl Chloride (PVC) Pipe and Fittings: ASTM D3034, SDR 21.
   1. Solvent cement: ASTM D2564.

C. High Density Polyethylene (HDPE) pipe and fittings: AASHTO M252, Type S; AASHTO M294, Type S.

D. Concrete: Comply with requirements of Section 033000.

E. High Density Polypropylene Pipe (HDPP):
   1. Dual wall pipe and fittings 12 inch through 24 inch diameter shall conform to ASTM F2736. Triple wall pipe 30 inch through 60 inch shall conform to ASTM F2881, except as otherwise specified herein.
   2. Pipe shall be joined using a bell & spigot joint meeting the requirements of ASTM F2881 or AASHTO M330. The joint shall be watertight according to the requirements of ASTM D3212. Gaskets shall meet the requirements of ASTM F477. Gasket shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gasket is free from debris. A joint lubricant available from the manufacturer shall be used on the gasket and bell during assembly. 12- through 60-inch (300 to 1500 mm) diameters shall have an exterior bell wrap installed by the manufacturer.
   3. Fittings shall conform to ASTM F2881 or AASHTO M330. Bell and spigot connections shall utilize a welded or integral bell and valley or inline gaskets meeting the watertight joint performance requirements of ASTM D3212.
   4. High Density Polyethylene Pipe (HDPE) is not equivalent to polypropylene pipe and shall not be considered as an acceptable substitute.

2.2 COMPONENTS

A. Junction Boxes: ASTM C858, precast reinforced concrete.
   1. Base section:
      a. Floor slab; 8 inch thick.
      b. Walls: 6 inch thick.
      c. Base riser section: 6 inch thick.
   2. Riser section: 48 inch diameter unless otherwise indicated on Drawings, with 6 inch thick walls.
   3. Top section: Concentric cone, eccentric cone, or flat slab type, as indicated on Drawings.
      a. Top of cone to match grade rings.
   4. Grade rings: Reinforced concrete rings, 4 to 9 inches thick.
   5. Gasket: ASTM C443, rubber.
   6. Steps: Cast iron steps, case into base, riser and top sections at 16 inch intervals.
   7. Frame and cover: ASTM A48, Class 35B gray iron.
      a. Frame size: 24 inch diameter, by 9 inch riser with 4 inch width flange.

b. Cover: 26 inch diameter, indented top design, with lettering “STORM SEWER” cast into cover.

8. Pipe connections: ASTM C923, resilient type.

B. Inlets: ASTM C858, precast reinforced concrete
1. Base section:
a. Floor slab: 8 inch thick.
b. Walls: 6 inch thick.
c. Base riser section: 6 inch thick.
2. Riser section: 48 inch diameter unless otherwise indicated on Drawings, with 6 inch thick walls.
3. Top section: Flat slab type.
a. Opening to match grade rings.
4. Grade rings: Reinforced concrete rings, 4 to 9 inches thick.
5. Gasket: ASTM C443, rubber.
6. Steps: Steel reinforced plastic steps, cast into base, riser and top sections at 16 inch intervals.
7. Pipe connections: ASTM C923, resilient type.

C. Yard Drains:
1. Size: 12 inches by 12 inches unless otherwise indicated on Drawings.
2. Body: ASTM F794, polyvinyl chloride (PVC).
3. Grate: ASTM A48, Class 30B cast iron, hinged type with traffic rating of H-20 approved for use in pedestrian applications.
4. Acceptable manufacturers and product:
a. Nyloplast America, Inc.: Inline Drain.
b. Comparable products of other manufacturers.

2.3 ACCESSORIES

A. Cleanouts: Cast-iron ferrule and countersunk brass cleanout plug, with round cast-iron access frame and heavy-duty, secured, scoriated cast-iron cover.

B. Underground Warning Tape: Polyethylene plastic tape, 6 inches wide by 4 mils thick.
1. Imprint warning tape with “CAUTION – SEWER SERVICE LINE BURIED BELOW” in large black letters.

C. Bedding Materials: As specified under Section 312000.

D. Backfill Materials: As specified under Section 312000.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper and timely completion.
1. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Trenching: Comply with requirements of Section 312000.
1. Grade trench bottom to provide smooth, firm, stable, and rock free foundation throughout length of pipe.
2. Remove unstable, soft, and unsuitable materials from surface upon which pipe is to lay.
a. Backfill with bedding material.
3. Shape bottom of trench to fit design of pipe.

a. Fill unevenness with tamped bedding material.
b. Dig bell holes at each pipe joint to assure continuous bearing of pipe.

B. Install bedding material at trench bottom in accordance with Section 312000.
1. Install bedding materials in continuous layers not exceeding 6 inches in compacted depth, to total depths indicated on Drawings.
2. Compact bedding materials as specified under Section 312000.

C. Pipe Installation: Comply with pipe manufacturers instructions.
1. Install pipe beginning at low point of system, true to grades and alignment indicated on Drawings and unbroken continuity of invert.
2. Install concrete pipe in accordance with ACPA Concrete Piping Installation Manual.
3. Install polyethylene corrugated pipe in accordance with ASTM D2321.
a. Install fittings in accordance with manufacturer's instructions.
4. Install PVC pipe in accordance with ASTM D2855 and ASTM F402.
5. Place bell ends or groove ends of piping facing upstream.
6. Install gaskets in accordance with manufacturer's instructions.
7. Install bedding at sides and over top of pipe to minimum compacted thickness of 12 inches.
8. Clean interior of piping as Work progresses.
9. Maintain swab or drag line and pull past each joint as it is completed.
10. Install plugs in ends of incomplete piping at end of each day.

D. Install junction boxes complete with accessories indicated on Drawings.
1. Comply with ASTM C891.
2. Form continuous concrete channel and benches between inlets and outlets.
3. Install top of frames and covers flush with adjacent paved surfaces.
a. Install top of frame flush with adjacent landscaped surfaces, unless otherwise indicated on Drawings.

E. Install inlets complete with accessories indicated on Drawings.
1. Comply with ASTM C891.
2. Form continuous concrete channel and benches between inlets and outlets.
3. Install top of frames and covers flush with adjacent paved surfaces.
a. Install top of frame flush with adjacent landscaped surfaces.

F. Install cleanouts and extension from storm drainage pipe to cleanout at grade at locations indicated on Drawings.
1. Set cleanout frame and cover in concrete pad, 18 inches by 18 inches by 12 inches deep except at where location is in concrete paving.
2. Set top of cleanout 1 inch above surrounding earth grade.
3. Set top of cleanout flush with surrounding pavement.

G. Tap Connections:
1. Make connections to existing storm sewer and underground structures to comply with requirements of this Section, as indicated on Drawings.

H. Install underground warning tape continuous buried 6 inches below finish grade, above pipe line.
1. Coordinate with Section 312000.

I. Backfilling: Comply with requirements of Section 312000.

3.3 PROTECTION

A. Protect installed sewage system from damage of displacement until backfilling operation is complete.

END OF SECTION

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SECTION 33 71 19 – UNDERGROUND DUCT BANKS

1. GENERAL

1.1 The scope of this document is to provide instruction for installation and testing of electric power duct banks and telecommunication systems duct banks installed on the University of Missouri campus.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this Section.

2. MATERIALS

2.1 Underground Ducts

A. Conduit

1. Underground concrete encased conduit duct banks shall consist of Type DB-60 or Schedule 40 polyvinyl chloride (PVC) conduit rated for 90°C cable and meeting NEMA Standard TC-6 and ASTM F-512 for underground applications.
2. Unless otherwise noted on the drawings, the standard conduit size shall be 3”, 4” or 5” for all conduits.
3. Conduits shall have long rigid steel metallic or fiberglass sweep elbows, 48” minimum radius for horizontal bends and 36” radius for vertical bends. Conduit elbows shall be PVC coated with taped ends.
4. All joints shall have watertight seals.
5. Conduit End Bells

    a. Conduit end bells for PVC conduit shall be polyvinyl chloride (PVC).
    b. Conduit end bells for rigid galvanized steel conduit shall be hot-dipped galvanized malleable iron or steel, threaded to the end of the rigid galvanized steel conduit.

B. Concrete

1. Color Additive

    a. The concrete for all concrete encased conduit **electric power** duct banks shall have a medium red color additive. The color additive shall have a minimum concentration per manufacturer’s recommendation per yard of concrete and shall be mixed throughout the entire duct bank concrete.
    b. Concrete for concrete encased conduit **telecommunications** duct banks shall have no color additive.

2. Admixtures

a. Air-entraining mixture shall be used for all exterior concrete and shall conform to ASTM C260. The total calculated air content by volume as determined by ASTM C231 shall be as follows:

Maximum Coarse Aggregate Size	Total Air Content, % Includes Trapped Air
3/4"	3-8
1"	4-6

b. Water reducing admixture shall be used to reduce the total water requirements. Water reducing admixture shall meet the requirements of ASTM C494, Type A.
c. Calcium chloride or accelerating admixtures containing calcium chloride shall not be used.
d. Proportioning

1) Concrete slump at the time of placement as determined by ASTM C13 shall be 3" to 4". Tolerance up to 1" above maximum will be allowed providing average of batches tested does not exceed maximum.
2) The minimum 28 day concrete compressive strength for concrete shall be 4,000 psi (6 sacks/cu. yd. minimum).

e. Reinforcement

1) All concrete encased electric conduit duct banks shall contain steel reinforcing throughout the entire length as indicated on Duct Bank Detail drawing. The minimum size of reinforcing steel shall be size No. 4.

f. Backfill

1) Backfill material shall be clean soil fill or ¾" minus waste rock fill. No concrete or large rocks are to be used. Backfill shall be compacted as installed.

3. ACCESSORIES

3.1 The pull string installed in spare electrical power conduits shall have a minimum of 240 lbs. tensile strength and shall be rot and mildew resistant. Pull string shall be made of nylon or polypropylene. Pull string shall have permanently printed sequential measurements at one foot increments.

3.2 All conduits for telecommunication duct banks shall be equipped with a minimum 1,500 lb strength mule-tape pull line. Pull line shall have permanently printed sequential measurements at one foot increments.

3.3 Use plastic plugs with wick for drainage to seal spare conduits in manholes.

A. Underground Warning Tape

1. Warning tape shall be fabricated from polyethylene film, and shall be 6 inches wide and not less than 3.5 mils thick.
2. For all electric power duct banks, warning tape shall be high visibility red in color and imprinted at frequent intervals with black letters having the following wording: CAUTION BURIED ELECTRICAL LINE BELOW
3. For all telecommunications duct banks, warning tape shall be high visibility orange in color and imprinted at frequent intervals with black letters having the following wording: CAUTION BURIED COMMUNICATIONS LINE BELOW

4. INSTALLATION

4.1 Conduit and Duct Banks

A. Conduit shall be adequately and properly supported on solid earth, or other indicated means, throughout the entire length of the run. All conduits shall be laid straight and true.

B. Verify routing locations of conduit prior to rough-in.

C. Couplings for conduits in a group shall be staggered at least six (6) inches.

D. Underground conduit duct banks shall be installed a minimum of 36” below finished grade to the top surface of the duct bank.

E. Underground conduit duct banks shall be at least 12 inches away from all other underground utilities; gas, water, electric, telephone, communications, etc., and at least 36 inches away from steam pipe lines and steam tunnels, trenches, or manholes.

F. Conduits shall be installed with a minimum slope of ½% toward manholes or other drainage points.

G. Intermediate and base spacers shall be used to obtain uniform separation and alignment during the installation of the concrete for concrete encased duct banks. Maximum intervals between spacers shall be 8 feet.

H. Concrete encased conduit duct bank penetrations into manholes shall continue completely through the wall of the manhole and shall use one large hole rather than several smaller holes. If this method is not practical, the concrete may stop outside the manhole but must be pinned to the manhole with steel pins to prevent any differential settlement.

I. Conduit end bells shall be installed at all conduit terminations in each manhole.

(1) Conduit end bells for PVC conduit shall be cast in place in the concrete wall of the manhole and glued to each end of each Type DB PVC conduit.

(2) Conduit end bells for rigid galvanized steel conduit shall be cast in place in the concrete wall of the manhole 3" between conduits and on outside including bottom.

4.2 Concrete

A. All duct banks used for 13.8Kv, 480/277V, or 208/120V systems shall be encased in **red** concrete.

B. All duct banks used for telecommunications systems shall be encased in **undyed** concrete.

C. Placing, Curing, and Backfill

1. Precautions shall be used to prevent ducts from floating.
2. Concrete shall be placed with the aid of a mechanical vibrator.
3. Curing shall be continued for at least 7 days in the case of all concrete except high-early-strength concrete for which the period shall be at least 3 days. Excavations should not be backfilled until concrete has cured.
4. In no cases shall ductbank sidewall thickness exceed 12" from side of duct.

D. Reinforcement

1. The reinforcing steel shall be installed longitudinally, at each corner of the duct bank (in cross section) and along the top and bottom and sides at a maximum of 12 inches on center. All reinforcing steel (including bottom) shall have a minimum concrete cover of 1-1/2 inches. Reinforcing shall be installed latitudinal, as needed, to hold the longitudinal steel in place during the placement of the concrete but no more than 48" apart. Refer to the Ductbank Details in the plans.

4.3 Accessories

A. All empty or "spare" conduits shall have a nylon or polypropylene pull string installed for future use. Leave not less than 2 feet of slack at each end of pull string.

B. Seal the ends of all conduits at manhole penetrations. Seal water tight with plastic plugs with wick for drainage. Conduit pull string shall penetrate through seal.

4.4 Underground Warning Tape

A. The location of all underground conduit duct banks shall be marked by burying one or more warning tapes below grade in the backfill. The warning tape shall be placed 18 inches above the top of the conduit(s) or duct bank and shall be parallel along the full length of the run.

B. If the widths of the conduits or duct bank is wider than 2 feet, two or more warning tapes shall be used, all in the same plane, spacing the tapes no more than 12 inches apart horizontally across the top width of the conduits or duct bank and equally spacing the tapes in from each longitudinal outer edge of the buried conduits or duct bank

5. TESTING

A. All duct banks shall be inspected by system owner prior to concrete placement.

B. Upon completion of the installation of each duct bank, demonstrate that all conduits are clear of obstructions by pulling a mandrel ½ inch smaller than the nominal size of the conduit through the entire length of each conduit.

6. COMMISSIONING

6.1 Electric Underground Duct

A. All soil and debris shall be removed from manholes and equipment pads where ductbanks terminate.

B. Verify all pull strings and caps are installed

END OF SECTION 33 17 19

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