

PROJECT MANUAL FOR:
**SOUTH FARM SWINE RESEARCH & EDUCATION FACILITY –
CONSTRUCT ADDITION**

PROJECT NUMBER:
CP230851

AT
UNIVERSITY OF MISSOURI - COLUMBIA
COLUMBIA, MISSOURI

FOR:
THE CURATORS OF THE UNIVERSITY OF MISSOURI

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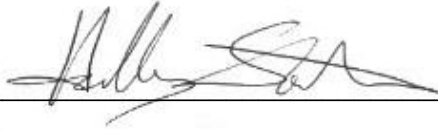
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DATE: April 12, 2024

VOLUME 2

I hereby certify that Drawing Sheets G0.00, G0.01, G0.10, G0.11, G0.30, A0.00, A0.11, A1.10, A1.11, A1.12, A1.13, A1.21, A1.30, A2.10, A3.10, A4.10, A6.10, A6.40, A8.10, F1.10, and Specification Sections 017419, 024119, 055051, 066000 & Specification Divisions 7-10 have been prepared by me, or under my supervision. I further certify that to the best of my knowledge these Drawings and Specifications are as required by and in compliance with Building Codes of the University of Missouri.

Signature: _____



4-12-24

I hereby certify that Drawing Sheets C0.51, C0.52, C1.01, C2.01, C3.01, C4.01, C4.11, C5.01, C5.02 and Specification Sections 01 57 13a, 01 57 13b, 31 10 00, 31 20 00, 31 23 19, 32 13 13, 32 13 73, 32 31 13, 32 91 19, 32 92 19, 33 31 00, 33 41 00, 33 46 13 have been prepared by me, or under my supervision. I further certify that to the best of my knowledge these Drawings and Specifications are as required by and in compliance with Building Codes of the University of Missouri.



Signature: _____

I hereby certify that Drawing Sheets S0.01, S1.01, S2.01, S3.01, S3.11, S3.21 and Specification Sections 031000, 032000, 033000, 042200, 055000, 061000, 061600, 061753 have been prepared by me, or under my supervision. I further certify that to the best of my knowledge these Drawings and Specifications are as required by and in compliance with Building Codes of the University of Missouri.

Signature: _____



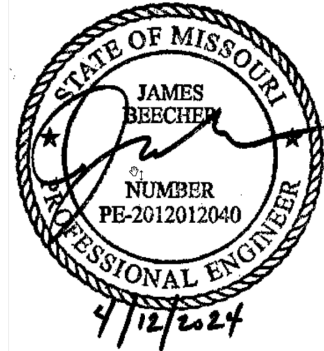
I hereby certify that Drawing Sheets C0.51, C0.52, C1.01, C2.01, C3.01, C4.01, C4.11, C5.01, C5.02 and Specification Sections 01 57 13a, 01 57 13b, 31 10 00, 31 20 00, 31 23 19, 32 13 13, 32 13 73, 32 31 13, 32 91 19, 32 92 19, 33 31 00, 33 41 00, 33 46 13 have been prepared by me, or under my supervision. I further certify that to the best of my knowledge these Drawings and Specifications are as required by and in compliance with Building Codes of the University of Missouri.



Signature: _____

I hereby certify that Drawing Sheets FS1.01, M0.00, M1.01, M1.02, M1.03, M2.01, M3.01, M4.01, M4.02, M4.03, M4.04, M5.01, M5.02, M6.01, M6.02, and Specification Division 21-23 have been prepared by me, or under my supervision. I further certify that to the best of my knowledge these Drawings and Specifications are as required by and in compliance with Building Codes of the University of Missouri.

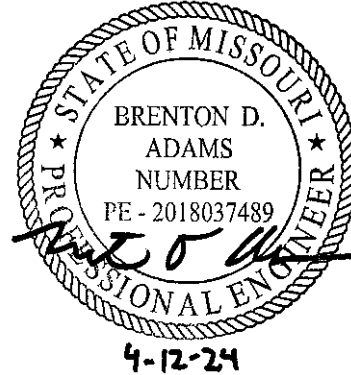
Signature: _____

A handwritten signature in black ink, appearing to read 'James Beecher', written over a horizontal line.

I hereby certify that Drawing Sheets E0.00, E0.01, E0.10, E1.11, E2.11, E3.01, E3.02, E4.01, E4.02, E5.01, E5.02, and Specification Divisions 26-28 have been prepared by me, or under my supervision. I further certify that to the best of my knowledge these Drawings and Specifications are as required by and in compliance with Building Codes of the University of Missouri.

Signature: _____

Brenton D. Adams



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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.

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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.

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- 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. System design and installation shall be supervised by a NICET Level III sprinkler system technician or fire protection engineer with not less than five (5) years of experience with sprinkler systems. All field installation work shall be continuously supervised by at least a NICET Level II in Water-Base Systems Layout. 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 ASME B31 Series "Code for Pressure Piping", including all addenda.
- F. Comply with provisions of NFPA 13, NFPA 14, NFPA 20, NFPA 24, and NFPA 25, including all addenda.
- G. 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.

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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

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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. Provide separate shop drawing submittals for all items listed in Shop Drawing and Submittal Log in Division 1.

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.

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- 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

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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.
- 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:

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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

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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).

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- 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

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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.

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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.

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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.

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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.

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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

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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	PIPI NG SYS TEM	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 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.

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1.5 QUALITY ASSURANCE

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

2. PRODUCTS

2.1 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.

2.2 STARTERS, ELECTRICAL DEVICES, AND WIRING

- 2.3 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.

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.

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- 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.

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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 21 05 13

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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. Pressure gauges shall be UL listed or FM approved for fire service.
- 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:

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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

FIRE SUPPRESSION GAUGES

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- 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 21 05 19

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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.

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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-hardening, non shrinking, UL listed.

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C. Firestop Compounds: Cementitious 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.

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- 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.

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- 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

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

END OF SECTION 21 05 29

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SECTION 21 05 53 – FIRE SUPPRESSION IDENTIFICATION

1. GENERAL

1.1 SECTION INCLUDES

- A. Nameplates.
- B. Tags.
- C. Pipe Markers.

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.

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2.2 TAGS

- A. Plastic Tags: Porcelain enameled 18 gauge and shall be affixed securely by corrosion-resistant chain to all valves. Tags shall be red (background) and white (lettering) in color. Tag size minimum 1-1/2 inch diameter or square.
- B. Chart: Approved, typewritten list that is plastic laminated and in frame and Plexiglas cover showing location and use of each valve, including drain valves. Valve list is to coordinate with mechanical piping schematics if provided on plans. The chart shall be secured in a visible location acceptable to the University.
- 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. Identify hose connections cabinets and drain termination points with plastic nameplates.
- C. Identification of valves:
 - 1. The main drain sign shall be labeled "MAIN DRAIN".
 - 2. Riser drains shall be labeled "RISER DRAIN" or "DRAIN"
 - 3. Auxiliary drain signs shall be labeled "AUXILIARY DRAIN"
 - 4. Inspector's test connection signs shall be labeled "INSPECTOR'S TEST".

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5. All water supply control valves shall have a standard sign identifying the portion of the system controlled, noting that the valve shall be kept open, and leaving a blank space for notification information.
6. All isolation valves shall be marked on identification tag whether valve is to be “normally open” (NO) or “normally closed” (NC).

D. Identification of piping:

1. All concealed pipe and exposed pipe that is not painted red shall be marked “Fire Protection”. Pipe markers shall be wrap-around type with white letters having a minimum of height of one inch (1”). All pipe markers must be visible from the floor. Spacing and location shall be:
 - a. Above Ceiling, Corridors: Every 20’ for mains. One (1) on each branch line.
 - b. Above Ceilings, Rooms: One (1) in every room on each branch line. Every 20’ for mains (at least one (1) in each room).
 - c. Exposed Areas, Non-painted Pipe: Every 20’ for mains and branch lines (at least one (1) on each branch line) and in each room.
 - d. Exposed Areas, Painted Pipe: Pipe markers not required if pipe is painted red. For any other color, comply with requirements above.
2. 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.

END OF SECTION 21 05 53

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SECTION 21 13 13 - FIRE SUPPRESSION SYSTEM

1. GENERAL

1.1 SECTION INCLUDES

- A. Pipe, fittings, valves, and connections for a combined automatic wet-pipe sprinkler system and wet-pipe standpipe system.
- B. System design, installation, and certification.
- C. Fire department connections.
- D. Post indicator valves.
- E. 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
- 3. NFPA 25 – Standard for the Inspection, Testing, and Maintenance of Water Based Fire Protection Systems.

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 entire building.

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- B. System shall be an automatic sprinkler system conforming to NFPA 13. Wet pipe 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.
 - 1. All storage areas shall be provided with automatic sprinkler protection. The protection design shall be determined at the time of construction and will be based on commodity type, storage configuration, storage height and building height.
- 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. Provide fire department connections as indicated. Coordinate fire department connection type with local fire department.
- F. 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 and standpipe system.

1.4 SUBMITTALS

- A. Shop Drawings: Shop Drawings shall be prepared in accordance with NFPA 13, NFPA 24 and FM Global Fire Suppression Data Sheets for approval of all equipment to be constructed and installed.
 - 1. 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.
 - a. Hydraulic calculations for standpipe systems shall comply with FM Global Data Sheet 3-26 and NFPA 13 and shall include comprehensive hydraulic data sheets. Provide a safety factor required by FM Global or 10 psi and 10%, whichever is greater, for all standpipe system hydraulic calculations.
 - b. Manufacturer's data sheets shall be provided for all materials and equipment for approval before purchase or installation. Data sheets shall describe the type of material, capacities, manufacturer, and part numbers of equipment and give sufficient information for equipment verification and approval.
 - 2. Shop drawings shall include ceiling grid or reflected ceiling layout and shall be coordinated with other trades prior to submittal.

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- B. 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.
- C. Submit shop drawings, product data, hydraulic calculations to authority having jurisdiction (local and state Fire Marshall if required). Submit proof of approval to Architect/Engineer. The contractor is responsible for receiving written acceptance for both plan review and final acceptance by the following departments:
- D. No work shall be performed until the University has approved the shop drawings, calculations, and data sheets. The contractor is solely liable for any work performed prior to this approval.

1.5 SYSTEM TESTING AND ACCEPTANCE:

- A. Three different system tests will be completed on any and all fire alarm systems.
 - 1. Preliminary testing: A preliminary test shall be completed by the installers to ensure proper operation of the fire suppression system valves and switches.
 - a. Prior to scheduling this test, the preliminary testing shall be completed.
 - b. Prior to scheduling this test as-built drawings, updated CAD files and O&M manuals shall be received by necessary parties.
 - c. The Contractor shall have all subcontractors scheduled to be in attendance on the day of inspection that will be needed in order to complete a 100% system test.
 - d. The contractor shall furnish all test equipment necessary to complete the testing.

1.6 WARRANTY AND TRAINING

- A. The contractor shall guarantee all workmanship and material free from inherent mechanical, defects for a period of 1 year from the date of acceptance as set forth in the general conditions.
- B. Failure to comply with all contractual obligations resulting in costs incurred by the University shall result in those costs being transferred to the appropriate contractor for payment.
- C. Contractor shall be financially responsible for all fees incurred to the university and all lost research due to false alarms or water leaks as a result of construction or contractor error for the duration of the warranty.
- D. Contractor shall provide services to instruct Owner's personnel in operation and maintenance of system for a minimum of two 4 hour sessions.

1.7 QUALITY ASSURANCE

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- A. **Manufacturer's Qualifications:** Firm regularly engages in the manufacture of fire suppression systems of types, sizes, and characteristics compatible with the current campus systems, and whose products have been in satisfactory use in similar service for not less than 5 years.
- B. **Designer and Installer Qualifications:** System design and installation shall be supervised by a NICET Level III sprinkler system technician or fire protection engineer with not less than five (5) years of experience with sprinkler systems. All field installation work shall be continuously supervised by at least a NICET Level II in Water-Base Systems Layout.
- C. **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.
- D. **Valves:** Bear UL and FM label or marking. Provide manufacturer's name and pressure rating marked on valve body.
- E. **Equipment and Components:** Each item of equipment shall be new and listed by Underwriters Laboratories (UL) and approved by FM Global. Each major item of equipment shall bear the manufacturer's name or trademark, serial number and UL or FM label. All materials and performance shall meet the appropriate ANSI, ASME and ASTM Codes.

1.8 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.

1.9 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, ABOVE GROUND

- A. **Steel Pipe:** ASTM A53 or ASTM A795; Schedule 40 galvanized steel. All dry and pre-action system piping and fittings shall be externally and internally galvanized.
 - 1. **Steel Fittings:** ANSI/ASME B16.5, steel flanges and fittings.

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2. Galvanized-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M, standard-weight, seamless steel pipe with threaded ends.
3. Couplings in "Galvanized-Steel Couplings" Paragraph below are generally available in NPS 1/8 to NPS 20 (DN 6 to DN 500).
4. Galvanized-Steel Couplings: ASTM A865/A865M, threaded.
5. Fittings in "Galvanized, Gray-Iron Threaded Fittings" Paragraph below are generally available in NPS 1/4 to NPS 12 (DN 8 to DN 300).
6. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
7. Cast Iron Fittings: ANSI/ASME B16.4, screwed fittings.
8. Malleable Iron Fittings: ANSI/ASME B16.3, screwed type.
9. Joints: Flanged, grooved or threaded.
10. Mechanical Grooved Couplings: Victaulic 005 Firelock Rigid rolled groove fittings or approved equivalent designed for a working pressure of 300 psi. Cut grooves or O-ring type socket fittings are not allowed.
 - a. Malleable iron housing clamps: ASTM A47; UL labeled; engage and lock; designed to permit some angular deflection, contraction, and expansion.
 - b. Galvanized couplings are required for galvanized pipe.
 - c. "C" shaped composition sealing gasket: ASTM D2000.
 - d. Steel bolts, nuts and washers: ASTM A183 heat treated with a minimum tensile strength of 110,000 psi.
 - e. Victaulic grooved couplings Style 009 not permitted on dry systems with air compressor

- 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.

2.2 FLEXIBLE SPRINKLER HOSE

A. 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 a mounting bracket and a 1-piece, leak tested sprinkler drop. The mounting bracket shall be compatible with application.
2. Flexible hose assembly shall be pressure/leak tested system available in 2' – 6' hose lengths.
3. All flexible hose assembly shall Factory Mutual (FM) approved and UL 2443 listed and are manufactured in an FM/UL audited facility.
4. Compatible with any FM/UL approved sprinkler head.
5. 100% leak tested system.
6. Industrial grade, all welded, no O-ring construction, with all stainless steel components.
7. Adjustable height and sprinkler alignment / center-of-tile uniformity.
8. Rated up to 300 psi (2066 kPa) with no additional hangers required.
9. Approved for use in suspended ceiling systems with light, medium and heavy load grids (ASTM C635, C636)

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10. True-bore 1" internal corrugated hose diameter, which produces friction loss values similar to hard pipe armovers.
11. IBC and SEI/ASCE 7-02 compliant for sprinklers installed in seismic design classes C and D/E/F.

B. 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. It shall have burst pressure of over 2000 psi.
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.

2.3 VALVES

- A. Unless specified otherwise, all valves shall be UL listed and/or FM approved and be suitable for the maximum anticipated system pressure or a minimum of 175 psi working pressure, whichever is greater.

B. Gate Valves

1. 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.
2. Over 2 Inches: Iron body, brass seats, trim, rising stem, handwheel, OS&Y, solid wedge disk, flanged or grooved ends, class 175, UL/FM approved.
 - a. Include tamper switches listed for use with OS&Y valves.

C. Angle Valves

1. 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.
2. 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.

D. Ball Valves

1. Up to and including 2 Inches: Forged brass two piece body, stainless steel ball, Teflon seats and stuffing box ring, vinyl-covered lever handle threaded ends, blowout proof stem, full port, 600 WOG, UL/FM approved.

E. Butterfly Valves

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1. Cast or ductile iron body, aluminum bronze disc, resilient replaceable EPDM seat, wafer or lug ends, extended neck, handwheel and gear drive and integral indicating device and built-in tamper proof switch rated, UL/FM approved.
 - a. The switch shall be contained within a NEMA Type 1, general purpose indoor rated housing. Either unauthorized removal of the switch housing (when the valve is open) or closing the valve, shall cause the switch contacts to change position.
 - b. The switch shall have four conductors to accommodate connections to Style 4 or Style 6 signaling line circuit devices.
 - c. Victaulic butterfly valves are acceptable if manufactured in the year 2010 or later.

F. Check Valves

1. Up to and including 2 Inches: Brass body and all brass fitted, swing disc, screwed ends, class 200, UL/FM approved.
2. Over 2 Inches: Iron body, brass trim, brass faced swing disc, renewable disc and seat, flanged, screwed or grooved ends, UL/FM approved.

G. Sprinkler System Control Valves

1. Cast- or ductile-iron body, flanged or grooved ends, 175 psig minimum pressure rating, UL/FM approved.

H. Drain Valves

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

2.4 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.
- B. Electric Alarm: Electrically operated red enameled gong with pressure alarm switch.
- C. Water Flow Switch: Electrically supervised vane type switch for mounting horizontal or vertical, with two contacts.
- D. Fire Department Connection:
 1. Type: Flush mounted wall type with polished brass finish. Coordinate exact type with local fire department.
 2. Outlets: Two way with thread size to suit local fire department hardware; threaded dust cap and chain of matching material and finish. Cover plate and eyelet cover not acceptable.

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3. UL/FM approved, class 250 Check valve with 3/4 inch automatic drip drain, connected to drain.
4. Drain: Automatic drip, discharged location(s) shown on drawings.
5. Escutcheon Engraving for Fire Department Connection: "AUTO SPRINKLER SYSTEM".
6. Supplemental Signage: Custom engraved polished brass sign secured to the building directly adjacent to fire department connection, reading "FDC SERVES SPRINKLER SYSTEM".

- E. Indicator Post: UL 789, FM approved, vertical type, cast iron body with operating wrench, extension rod. Provide adjustable cast iron barrel of sufficient length to allow for bury depth of valve and surface elevation.

1. Tamper switch monitored by the associated building fire alarm panel.
2. 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.
3. 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.

- F. 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.

2.5 FLOW ALARM SWITCHES

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

2.6 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.

- 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.

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C. Sprinkler Finishes/Coating:

1. PTFE (corrosion resistant).

D. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Install concealed sprinkler heads in all lobbies, corridors, and student study/gathering areas. 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.

E. 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. See drawings for additional locations for sprinkler head guards.
3. Standard: UL 199.
4. Type: Wire cage with fastening device for attaching to sprinkler.

2.7 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.

3. EXECUTION

3.1 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel 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.

3.2 INSTALLATION

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- A. Install piping in accordance with NFPA 13 and NFPA 24 as applicable.
- B. Each underground pipe joint or connection shall include a compression-type joint restraint device (Mega Lug or equal). Any changes in direction of underground piping shall be provided with a thrust block or joint restraint as required per NFPA 13 and NFPA 24. Changes in direction where entering buildings shall be provided with both thrust blocks and joint restraint. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient. Place pipe runs to minimize obstruction to other work.
- C. 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.
- D. Sprinkler locations shown on drawings are recommendations only. Sprinkler/standpipe 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.
- E. 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.
 - 1. Piping in all occupied areas and mechanical area passageways shall not be lower than 7'-6". Specific written approval may be granted for unavoidable projections, but under no circumstance shall overhead piping be installed lower than 6'-8" above the floor.
- F. Piping shall not reduce the required width of any means of egress. The width of stairs or clear width of a corridor or passageway shall not be less than 44 inches
- 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.

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- 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. All valves in the sprinkler system shall be UL listed and/or FM approved butterfly, gate or ball type indicating valves except for the following, which shall be OS&Y:
 - 1. All indicating valves on the suction side of a fire pump.
 - 2. Where indicated on the contract drawings.
 - 3. Backflow device can have either OS&Y or butterfly valves unless it is on the suction side of a fire pump.
- P. Provide gate, ball or butterfly valves for shut-off or isolating service.
- Q. Provide drain valves at main shut-off valves, low points of piping and apparatus.
- R. Pipe main system drain valve and test connection to location outside building. See drawings.
- S. Install equipment in accordance with manufacturer's instructions.
- T. Install buried shut-off valves in valve box. Provide post indicator.
- U. Provide backflow preventer as shown on drawings.
- V. Locate fire department connection with sufficient clearance from walls, obstructions, or adjacent fire department connections to allow full swing of fire department wrench handle.
- W. Install outside alarm gong on building wall in location coordinated with the Architect / Engineer.
- 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, at each sprinkler test connection, and at top of each standpipe.

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- AA. Install all valves, flow switches, and other accessories in accessible locations. Where these components are located in a concealed area, provide access panels.
- BB. Sprinkler or standpipe piping shall not be installed above any electrical panels, electrical transformers, fire alarm panels, or BMS panels, regardless of distance above.
- CC. Except for underground water supply valves located in roadway boxes, all valves controlling water supply to sprinklers shall be supervised by the fire alarm system.
- DD. A control valve shall be installed at the base of each riser, no higher than 7 feet.
- EE. System shall be zoned according to location and each zone shall be annunciated at the building fire annunciator and installed to NFPA regulations. Separate zones shall be provided for each flow switch and tamper switches.
- FF. Backflow Preventer:
 - 1. A double check backflow prevention assembly shall be installed prior to any sprinkler or standpipe system connected to the City of Fort Collins water distribution system, including connection of pressure maintenance pumps to the building's domestic water line used to fill sprinkler system piping. Reduced pressure backflow required on High Hazard Systems.
- GG. Sprinklers:
 - 1. Sprinklers shall be UL listed or FM approved and shall not include O-ring seals. Any sprinkler that incurs damage, is painted, or is sprayed with any obstructive material during construction shall be replaced at no cost to the University. Installation of sprinklers shall be coordinated with other work, including duct and electric fixture installation, to prevent sprinkler obstructions.
 - 2. Sprinklers located less than eight feet above finished floor or that may be subject to mechanical damage shall be provided with guards listed for use with the model of sprinkler installed.
 - 3. Quick-response sprinklers are required throughout all light-hazard occupancies, and may also be installed in ordinary-hazard occupancies for the quick response hydraulic design area reduction per NFPA 13 for utilizing quick response sprinklers. Extended coverage sprinklers may be used if proven in the hydraulic calculations.
 - 4. Install sprinkler storage cabinet in mechanical room. Coordinate location with other trades.

3.3 FIELD QUALITY CONTROL

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

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- B. The Contractor is responsible for assuring all inspections are recorded on the project Building Inspection Record at the time of inspection. This applies both to successful and failed inspections Aboveground Pipe.
- C. All underground pipe connecting sprinkler systems to the City of Fort Collins. Pipe shall be hydrostatically tested for 2 hours at 200 psi, including fire department connections per NFPA 24.
- D. Perform a system test with a fire department pumper truck to verify acceptable pressure (typically 100 psig) at the most-remote standpipe hose connection. Connect pumper truck to fire department connection for test. Coordinate with authority having jurisdiction and local fire department.
- E. 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.
- F. 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 21 13 13

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SECTION 22 05 00 - BASIC PLUMBING REQUIREMENTS

1. GENERAL

1.1 SECTION INCLUDES

- A. This section describes Basic Plumbing 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 Plumbing Division of the Specifications that all plumbing 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.

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- 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 PERMITS

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

1.5 QUALITY ASSURANCE

- A. Installers shall have at least 5 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.

1.6 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:

BASIC PLUMBING REQUIREMENTS

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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.

1.7 SUBMITTALS

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

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- 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 Plumbing 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.
- E. Provide separate shop drawing submittals for all items listed in Shop Drawing and Submittal Log in Division 1.

1.8 SUBSTITUTES

- A. Refer to the General Conditions and Special Conditions sections of this Specification for general substitution requirements and information.

1.9 WARRANTY

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

1.10 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.
- 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.

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

1.11 AS-BUILT 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.

1.12 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.

2. PRODUCTS (NOT APPLICABLE).

3. EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

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- 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. 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.

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- 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.

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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.
6. Obtain proper hot work permits as required.

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. Owner's Representative
 2. Mechanical Engineer / Architect
 3. General Contractor's Foreman

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- 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. Test duration shall be 1 hour.
- 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 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.
- 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. 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. Under no circumstances shall any structural members, load-bearing walls or footings be cut without first obtaining written permission from the Engineer.
 - 4. 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.

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5. Patching of concrete openings shall be filled with grout and finished smooth with the adjacent surface.
6. All below-grade openings for pipe shall be sealed with interlocking synthetic rubber line assembly, Link-Seal by Thunderline Corporation or equal.
7. Repair cut surfaces to match adjacent surfaces.
8. 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. 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.
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. 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.
8. 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.
9. Contractor shall provide temporary supports for all underground utilities crossing an excavation.
10. Provide all required barricades, fencing, signs, lights, etc. as necessary for the protection of the workers and of the general public.

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11. Excess Material: All excess earth and other material resulting from the excavation shall be removed from site daily by the Contractor.
12. 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.

D. Painting

1. Contractor is to field paint plumbing equipment and materials in specified areas as noted on the plumbing plans, plumbing schedules and in the specifications.
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 099100.

- E. The responsibility of work specified under Division 22 and 26 is clarified under, Section 220513, "Electrical Requirements for Plumbing Equipment. Contractor is to coordinate all electrical requirements prior to ordering powered plumbing equipment.

END OF SECTION 22 05 00

PIPE PRESSURE TEST LOG											
PROJECT:											
BUILDING:						GENERAL CONTRACTOR:					
CLARK ENERSEN PROJECT NUMBER:						MECHANICAL CONTRACTOR:					
TEST INFORMATION						TEST PRESSURE					
TEST DATE	PIPI NG SYS TEM	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 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. ANSI/NFPA 70 - National Electrical Code.
 - b. NEMA Standard ICS 2 – Industrial Control Devices, Controllers, and Assemblies.
 - c. NEMA Standard 250 – Enclosures for Electrical Equipment.
 - d. 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.

1.2 SUMMARY

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- 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 SAFETY SWITCHES

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

3. EXECUTION

3.1 CONTRACTOR COORDINATION

- A. General contractor is responsible for coordination of all subcontractors and associated scopes of work.

END OF SECTION 22 05 13

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SECTION 22 05 19 – PLUMBING METERS AND GAUGES

1. GENERAL

1.1 SECTION INCLUDES

- A. Pressure gauges and pressure gauge taps.
- B. Thermometers and thermometer wells.
- C. Piping pressure and temperature test plugs.

1.2 REFERENCE SECTION 22 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

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.

PLUMBING METERS AND GAUGES

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

2.4 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, magnifying lens, with non-mercury fluid.
- 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.

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.

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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.

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 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.

3.3 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.

3.4 TEST PLUGS

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

3.5 ADJUSTING AND CLEANING

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

PLUMBING METERS AND GAUGES

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- 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 22 05 19

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SECTION 22 05 29 – PLUMBING 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. Flashing and sealing equipment and pipe stacks.
- E. Sealants, firestop insulation, putty and compounds.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

- A. References
- B. Submittals
- C. Delivery, storage and handling

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. Pure Water Piping and Laboratory Waste and Vent Piping:
 - 1. Conform to manufacturer's recommendations 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.

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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. Hangers for insulated pipe shall be enlarged to compensate for insulation thickness so that hangers support insulation. See Section 22 07 19.
16. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
17. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
18. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
19. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
20. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
21. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
22. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
23. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
24. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
25. Side-Beam Brackets (MSS Type 34): For sides of steel beams.
26. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
27. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
28. See Section 22 05 48 for vibration isolation hangers and supports.

2.2 ACCESSORIES

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

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2.3 INSERTS

- 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)

2.4 FLASHING

- A. Metal Flashing: 26 gage galvanized steel.
- B. Metal Counterflashing: 22 gage galvanized steel.
- C. Flexible Flashing: 47 mil thick sheet butyl; compatible with roofing.
- D. Floor Drain and Floor Sink Flashing: 40 mil thick chlorinated polyethylene (CPE), equivalent to Chloraloy.
- E. Caps: Steel, 22 gage minimum; 16 gage at fire resistant elements.

2.5 SLEEVES

- A. Sleeves for Pipes Through Rated Floors and Walls: Schedule 40 steel pipe.
- B. Sleeves for Pipes Through Non-Rated Floors: Schedule 40 steep pipe, extended 2" above floor.
- C. Sleeves for Pipes Through Non-Rated Beams, Walls, Footings, and Potentially Wet Floors: Steel pipe or 18 gage galvanized steel, extended 2" above floor. See drawings for further detail.

2.6 SEALANTS, FIRESTOP INSULATION, PUTTY, AND COMPOUNDS

- A. Refer to Section 07 84 13 for firestopping materials and methods. Refer to drawings for additional details.
- B. Sealants:
 - 1. Non fire/smoke rated partitions: Acrylic or silicone based caulking.
 - 2. Fire/smoke rated partitions: Silicone based caulking, UL listed.

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- C. **All fire-rated sealants and firestops shall be installed by a certified firestop contractor. Reference front-end specifications for further information.**

2.7 MECHANICAL SEALS

- A. Mechanical Seals: Modular mechanical type, consisting of interlocking low durometer 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, Link-Seal LS-316, or approved 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, Century-line Model CS, or approved 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, Century-line Model WS, 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

PLUMBING HANGERS AND SUPPORTS

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- 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.
- 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. 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.
- O. 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:

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<u>NPS</u>	<u>LENGTH</u>	<u>THICKNESS</u>
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.

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.

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- 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.

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- 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

- 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.

END OF SECTION 22 05 29

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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:

- A. Commissioning requirements.
 - 1. See section 01 91 13 – General Commissioning Requirements for all commissioning requirements.
- B. References
- C. Related Sections
- D. Submittals
- E. Quality Assurance

1.3 PROJECT RECORD DOCUMENTS

- A. 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

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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 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.

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- 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 $\frac{3}{4}$ " 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. Provide ceiling stickers or machine generated labels to locate valves, dampers, or HVAC equipment above T-bar type panel ceilings. Locate ceiling sticker on the ceiling grid closest to equipment. Label each sticker with the device located above the ceiling, i.e. VBR-33.

END OF SECTION 22 05 53

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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:

- A. References
- B. Submittals
- C. Delivery, Storage and Handling

1.3 QUALITY ASSURANCE

- A. See Section 22 05 00.
- B. Materials: Flame spread/smoke developed rating of 25/50 or less in accordance with ASTM E84, NFPA 255, and UL 723.

1.4 ENVIRONMENTAL REQUIREMENTS

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

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.

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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: Air dried, contact adhesive, compatible with insulation.

2.2 JACKETS

- A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.
- B. PVC Plastic: High-impact-resistant; UV-resistant PVC complying with ASTM D 1784, Class 16354-C; One piece molded type fitting covers and sheet material, white color.
1. Minimum Service Temperature: -40 degrees F.
 2. Maximum Service Temperature: 150 degrees F.
 3. Moisture Vapor Transmission: ASTM E96; 0.002 perm inches.
 4. Maximum Flame Spread: ASTM E84; 25.
 5. Maximum Smoke Developed: ASTM E84; 50.
 6. Thickness: 20 mil.
 7. Connections: Brush on welding adhesive or pressure sensitive color matching vinyl tape.
 8. Covering Adhesive Mastic: Compatible with insulation.

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. For elastomeric insulation systems, use inserts by the same manufacturer of the insulating system being installed (i.e. for Armaflex, use Amaflox.)
- C. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance of tests.

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- D. 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.
- E. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.
- F. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.
- G. 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.
- H. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.
- I. Where piping passes through fire walls indicated on the contract drawings, contractor shall install firestopping per firestop manufacturers instructions.
- J. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.
- K. Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.
- L. 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.
- M. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.
- N. Wood blocking shall not be used.
- O. On exposed piping, locate insulation and cover seams in least visible locations.
- P. 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.

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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.**

Q. Finish insulation at supports, protrusions, and interruptions.

R. For pipe exposed in finished areas, finish with white PVC jacket and PVC fitting covers.

S. For piping exposed in mechanical rooms below 8 feet above finished floor, finish with PVC jacket and covers.

T. 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.

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

<u>PIPING SYSTEM:</u>	<u>PIPE SIZE:</u>	<u>THICKNESS:</u>
Cold Water Systems	All sizes	1"
Tempered Water Systems	All sizes	1"
Cold (<65° F) Condensate Drain Piping	All sizes	1"
Fire Sprinkler System Main Drain and Inspector's Test Valve Drain Within 20' of Building Exterior	All sizes	1"
Hot Water and Hot Water Recirc Systems	1-1/4" & smaller	1"
Hot Water and Hot Water Recirc Systems	1-1/2" & larger	1-1/2"

END OF SECTION 22 07 19

University of Missouri
South Farm Swine Research & Education Facility – Construct Addition
Columbia, MO

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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. Domestic water piping system
- E. Pressure washer piping

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.

1.4 ENVIRONMENTAL REQUIREMENTS

- A. Do not install underground piping when bedding is wet or frozen.

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1.5 EXTRA MATERIALS

- A. Provide two repacking kits for each size valve.

2. PRODUCTS

2.1 SANITARY WASTE AND VENT PIPING, BURIED

- 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 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: ASTM B32, solder, Grade 95TA, for piping 1-1/2" and smaller. AWS A5.8, BCuP-5 (15% silver bearing material) silver braze, for piping 2" and larger.
 3. Copper Pressure-Seal-Joint Fittings
 - a. Viega, Press Fit or equivalent
 - b. Fittings for pipes 2" and smaller: Wrought-copper fittings with EPDM-rubber, O-ring seal in each end.
 - c. Fittings for pipes 2" and larger: Cast-bronze or wrought-copper fittings with EPDM-rubber, O-ring seal in each end.

2.4 INDUSTRIAL COLD WATER

- A. PVC, Schedule 40 Pipe: ASTM D1785.
1. PVC, Schedule 40 Socket Fittings: ASTM D2466.

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B. PVC, Schedule 80 Pipe: ASTM D1785.

1. PVC, Schedule 80 Socket Fittings: ASTM D2467.
2. PVC, Schedule 80 Threaded Fittings: ASTM D2464.

C. PVC, AWWA Pipe: AWWA C900, [Class 150] [and] [Class 200], with bell end with gasket, and with spigot end.

1. Comply with UL 1285 for fire-service mains if indicated.
2. PVC Fabricated Fittings: AWWA C900, [Class 150] [and] [Class 200], with bell-and-spigot or double-bell ends. Include elastomeric gasket in each bell.
3. PVC Molded Fittings: AWWA C907, Class 150, with bell-and-spigot or double-bell ends. Include elastomeric gasket in each bell.
4. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - a. Gaskets: AWWA C111, rubber.
5. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - a. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

2.5 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. Copper tube and pipe: 150 psig slip-on bronze flanges; 1/16 inch thick preformed neoprene gaskets.

2.6 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.

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2.7 NATURAL GAS PIPING, BELOW 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.
 - 3. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
 - a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

2.8 VALVE BOXES:

- A. Cast-iron, two-section box.
 - 1. Top section with cover with "GAS" lettering.
 - 2. Bottom section with base to fit over valve and barrel a minimum of 5 inches (125 mm) in diameter.
 - 3. Adjustable cast-iron extensions of length required for depth of bury.
 - 4. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.9 DIELECTRIC CONNECTIONS:

- A. Dielectric Nipples: Where connecting ferrous and non-ferrous piping materials, use dielectric nipples conforming to the following specifications to separate piping materials:
 - 1. Standard: IAPMO PS 66.
 - 2. Electroplated steel nipple complying with ASTM F 1545.
 - 3. Pressure Rating and Temperature: 300 psig at 225 deg F.
 - 4. End connections: Male threaded.
 - 5. Lining: Inert and noncorrosive, propylene.

2.10 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.

2.11 BALL VALVES

- A. Up to and including 4 inches: Bronze two piece body, chrome plated steel full-port ball, teflon seats and stuffing box ring, lever handle.

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2.12 BUTTERFLY VALVES

- A. 3 Inches and larger:
 - 1. Standard: MSS SP-67, Type I.
 - 2. Body Design: Lug type suitable for bidirectional dead-end service rated at 200 psig without use of downstream flange.
 - 3. Body Material: ASTM A 536, ductile iron.
 - 4. Seat: EPDM
 - 5. Stem: One or two piece stainless steel.
 - 6. Disc: Neoprene coated ductile iron or aluminum bronze.

2.13 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.

2.14 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 1/4" 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 valves to be provided with molded insulation to permit access for balance and read-out.

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.

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- C. 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 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.

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- I. Provide access where valves and fittings are not exposed.
- J. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
- K. Prepare pipe, fittings, supports, and accessories not prefinished, ready for finish painting.
- L. Install bell and spigot pipe with bell end upstream.
- M. Install valves with stems upright or horizontal, not inverted.
- N. Extend chains on valves with chainwheel operators down to maximum 5-feet above finished floor.
- O. Install strainers in horizontal pipe or in vertical pipe such that flow is downward. Do not install strainers in vertical pipe with flow upward.
- P. Install copper tubing under building slab according to CDA's "Copper Tube Handbook." Install ball valve directly upstream of each floor slab penetration.
- Q. Install underground copper tube in PE encasement according to ASTM A 674 or AWWA C105.
- R. Install ball valve at all laboratory water connections to fume hoods and other laboratory equipment.
- S. 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.
- T. Provide dewatering as necessary to accommodate the electrofusion joint-making process for all underground laboratory waste piping.
- U. Install PVC, AWWA pipe according to ASTM F645 and AWWA M23.
- V. Install hangers for PVC piping with maximum horizontal spacing and minimum rod diameters to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- W. Support vertical runs of PVC piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

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.

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- C. Install ball valves for throttling, bypass, or manual flow control services.
- D. Provide flow control valves in water recirculating systems where indicated. Balance flow to maintain hot water at all plumbing fixtures.
- E. Support storm piping at roof drains independent of drain.

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

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- A. Provide new sanitary service. 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.
 - 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.
- C. Provide new 5 psi gas service. Meter and regulator provided by gas company and paid for by contractor.

END OF SECTION 22 10 00

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SECTION 22 11 19 - PLUMBING SPECIALTIES

1. GENERAL

1.1 SECTION INCLUDES

- A. Backflow preventers.
- B. Automatic flow balance valves.
- C. Installation requirements of other plumbing specialties scheduled in Plumbing Fixture Schedule.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

- A. References.
- B. Submittals.
- C. Project record documents
 - 1. Record actual locations of plumbing specialties.
- D. Operation and maintenance data.
- E. Qualifications
- F. Delivery, storage and handling.

2. PRODUCTS

2.1 BACKFLOW PREVENTERS

- A. Reduced-Pressure-Zone Assembly Backflow Preventers
 - 1. The assembly shall consist of an internal pressure differential relief valve located in a zone between two positive seating check modules with captured springs and silicone seat discs. Seats and seat discs shall be replaceable in both check modules and the relief valve. There shall be no threads or screws in the waterway exposed to line fluids. Service of all internal components shall be through a single access cover secured with stainless steel bolts. Lead Free* reduced pressure zone assembly shall comply with state codes and standards, where applicable, requiring reduced lead content. The assembly shall also include two resilient seated isolation valves, four resilient seated test cocks and an air gap drain fitting. The

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- assembly shall meet the requirements of: USC; ASSE Std. 1013; AWWA Std. C511; CSA B64.4.
2. Operation: Continuous-pressure applications.
 3. End Connections:
 - a. Threaded for NPS 2 and smaller;
 - b. Flanged for NPS 2-1/2 and larger.
 4. Accessories:
 - a. Up to 2":
 - 1) Quarter-turn ball valves: full port, resilient seated, lead free cast copper silicon alloy body;
 - 2) Strainer;
 - 3) Air-gap fitting.
 - b. 2-1/2" to 3":
 - 1) Non-rising stem resilient (NRS) gate valves.
 5. Materials:
 - a. Up to 2": Lead Free copper silicon alloy body construction, silicone rubber disc material in the first and second check plus the relief valve. Replaceable polymer check seats for first and second checks. Removable stainless steel relief valve seat. Stainless steel cover bolts.
 - b. 2-1/2" to 3":
 - 1) Epoxy coated cast iron unibody with plastic seats;
 - 2) Relief valve with stainless steel seat and trim;
 - 3) Lead-Free cast copper silicon alloy body ball valve test cocks.
 6. Pressure / Temperature:
 - a. Up to 2": Suitable for supply pressure up to 175 psi. Water temperature: 33 deg F to 180 deg F.
 - b. 2-1/2" to 3": Suitable for supply pressure up to 175 psi and water temperature at 110 deg F continuous, 140 deg F intermittent.

2.2 AUTOMATIC FLOW BALANCE VALVES

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- A. Externally adjustable balance valve with removable differential pressure cartridge and external locking handle. Flow cartridge must be removable from valve without removing the valve from piping. Valve equipped with two capped 1/4" readout valves. NPT end connections. Brass body with stainless steel spring, HNBR diaphragm and EPDM o-rings. MWP of 300 psig, temperature range of 14 to 250 degrees F., +/- 5% accuracy. Valves shall be identified with flow rate, pressure operating range, and coil designation.
- B. Manufacturer: Bell and Gossett Ultraset or equivalent.

2.3 OTHER SPECIALTIES

- A. Refer to Plumbing Specialties Schedule for required product information.

3. EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Pipe relief from backflow preventers to nearest drain.
- C. 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.
- D. Provide final certification for all testable backflow preventers, after installation, by certified cross connection device tester. Submit copy of successful test to owner representative.

END OF SECTION 22 11 19

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SECTION 22 21 23 - PLUMBING PUMPS

1. GENERAL

1.1 SECTION INCLUDES

- A. Booster 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.
- 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

2.1 BOOSTER PUMPS

- A. Booster pump, associated expansion tank, and all other devices/items that are required for pump to operate shall be provided as part of pre-fabricated pump skid.

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1. All individual pumps on pump skid shall be provided with means to isolate the individual pump if/when maintenance is required.
2. See Booster Pump Schedule on plumbing drawings for information/characteristics of pump package

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.

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. 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.
- 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 40 00 - PLUMBING FIXTURES

1. GENERAL

1.1 SECTION INCLUDES

- A. Cleanouts.
- B. Water hammer arresters.
- C. Floor drains, floor sinks and trench drains.
- D. Hose bibs and wall hydrants.
- E. Combination electric water coolers / bottle filling stations.
- F. Installation requirements of plumbing fixtures scheduled in Plumbing Fixture Schedule.
- G. Plumbing fixture carriers.

1.2 REFERENCE SECTION 22 05 00 FOR THE FOLLOWING:

- A. Commissioning requirements.
 - 1. See section 01 91 13 – General Commissioning Requirements for all commissioning requirements.
- B. References
- C. Submittals
- D. Quality Assurance
- E. 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

PLUMBING FIXTURES

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2.1 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, medium duty nickel bronze top to accommodate the following floor finishes as required:
 - 1. Exposed rim type with recess to receive terrazzo 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.

2.2 WATER HAMMER ARRESTERS

- A. Standard: ASSE 1010 or PDI-WH 201.
- B. Type: Diaphragm type.
- C. Size: Size per manufacturer recommendations.

2.3 FLOOR DRAINS, FLOOR SINKS, AND TRENCH DRAINS

- A. Refer to Plumbing Fixture Schedule for required product information.
- B. Minimum floor drain size shall be 3" diameter.

2.4 HOSE BIBBS AND WALL HYDRANTS

- A. Refer to Plumbing Fixture Schedule for required product information.

2.5 OTHER PLUMBING FIXTURES

- A. Refer to Plumbing Fixture Schedule for all required product information.

2.6 PLUMBING FIXTURE CARRIERS

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- A. All wall mounted fixtures such as urinals, water closets, lavatories, drinking fountains, electric water coolers, 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. Verify that walls and floor finishes are prepared and ready for installation of fixtures.
- B. 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.
- B. Coordinate cutting and forming of roof and floor construction to receive drains to required invert elevations.

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.

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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.
- B. Install supports, affixed to building substrate, for wall-mounted lavatories and sinks.
- C. 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.
- D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings.
- E. Seal joints between lavatories/sinks, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color.
- F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories and sinks.

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G. 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 CLEANOUT INSTALLATION

- A. 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.
- B. Encase exterior cleanouts in concrete flush with grade.

3.7 WATER HAMMER ARRESTOR INSTALLATION

- A. Install water hammer arrestors complete with accessible isolation valve according to PDI-WH 201 and as shown on drawings.

3.8 FLOOR DRAIN INSTALLATION

- A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
- B. Position floor drains for easy access and maintenance.
- C. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
1. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
 2. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
 3. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
- D. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.

3.9 INTERFACE WITH OTHER PRODUCTS

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

3.10 ADJUSTING

- A. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.

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- 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.

3.11 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 22 40 00

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SECTION 23 05 00 - BASIC HVAC 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 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

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Architect/Engineer before proceeding with the work.

1.4 QUALITY ASSURANCE

- A. Installers shall have at least 5 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.

1.5 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.

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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.

1.6 SUBMITTALS

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

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recommendations.

- D. Shop drawings shall include the minimum following information as applies. Additional specific information required is outlined in other Plumbing 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.
- E. Provide separate shop drawing submittals for all items listed in Shop Drawing and Submittal Log in Division 1.

1.7 SUBSTITUTES

- A. Refer to the General Conditions and Special Conditions sections of this Specification for general substitution requirements and information.

1.8 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.

1.9 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.

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- 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: Air Handling Units, Exhaust Fans, and Heat Recovery Housing.
- 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.

1.10 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

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- 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.

1.11 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.

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.

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- 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.

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- 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

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- 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. Owner's Representative
 - 2. Mechanical Engineer / Architect
 - 3. 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

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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 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.

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. 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. Under no circumstances shall any structural members, load-bearing walls or footings be cut without first obtaining written permission from the Engineer.
- 4. 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.
- 5. Patching of concrete openings shall be filled with grout and finished smooth with the adjacent surface.
- 6. All below-grade openings for pipe shall be sealed with interlocking synthetic rubber line assembly, Link-Seal by Thunderline Corporation or equal.
- 7. Repair cut surfaces to match adjacent surfaces.
- 8. 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.

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- f. Upon written instructions from the Architect, uncover and restore Work to provide for Architect/Engineer observation of concealed Work.

C. Concrete Bases

1. Minimum 4" high concrete housekeeping pads shall be provided under floor mounted mechanical equipment.
2. 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."

D. Painting

1. Contractor is to field paint HVAC equipment and materials in specified areas as noted on the HVAC plans, HVAC schedules and in the specifications.
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 099100.

- E. The responsibility of work specified under Division 23 and 26 is clarified under, Section 230513, "Electrical Requirements for Mechanical Equipment. Contractor is to coordinate all electrical requirements prior to ordering powered mechanical equipment.

END OF SECTION 23 05 00

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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.

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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

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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. Explosion proof motors shall be provided as indicated on plans and schedules.
 - e. 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.

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12. Motors less than 1 hp: Motor shall be an electronic commutation (EC) motor specifically designed for HVAC applications. AC induction type motors are not acceptable. Examples of unacceptable motors are: Shaded Pole, Permanent Split Capacitor (PSC), Split Phase, Capacitor Start and 3 phase induction type motors. Motors shall be permanently lubricated with heavy-duty ball bearings to match the fan load and prewired to the specific voltage and phase. Internal motor circuitry shall 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 on the motor or by a 0-10 VDC signal. Motor shall be a minimum of 85% efficient at all speeds.

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

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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 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.

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- 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. General contractor is responsible for coordination of all subcontractors and associated scopes of work.

END OF SECTION 23 05 13

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SECTION 23 05 19 – HVAC METERS AND GAGES

1. GENERAL

1.1 SECTION INCLUDES

- A. Pressure gages and pressure gage taps.
- B. Thermometers and thermometer wells.
- C. Piping pressure and temperature test plugs.
- D. 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

2. PRODUCTS

2.1 PRESSURE GAUGES

- 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.

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- 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.

2.2 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 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. Heating Water: 30 to 250 deg with 2-degree scale.
 - 2. Chilled Water: 0 to 100 deg F with 2-degree scale divisions.
 - 3. Steam and Condensate: 50 to 400 deg F with 2-degree scale divisions.

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2.4 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.

2.5 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.

2.6 STATIC PRESSURE GAUGES

- 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 diameter tubing.
- C. Construction: Bronze or stainless-steel body, with sight glass and ball indicator, and threaded or flanged ends.
- D. Minimum Pressure Rating: 150 psig.
- E. Minimum Temperature Rating: 200 deg F.
- F. End Connections for NPS 2 and Smaller: Threaded.
- G. End Connections for NPS 2-1/2 and Larger: Flanged.

3. EXECUTION

3.1 GENERAL

- A. Install in accordance with manufacturer's instructions.

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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 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.

3.4 TEST PLUGS

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

3.5 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 23 05 19

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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. Mechanical sleeves and seals.
- D. Flashing and sealing equipment and pipe stacks.
- E. 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. Refrigerant Piping

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1. Conform to International Mechanical Code, ASME B31.1, 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. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
18. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
19. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
20. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
21. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
22. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
23. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
24. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
25. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
26. Side-Beam Brackets (MSS Type 34): For sides of steel beams.
27. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

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28. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
29. 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 (Table 5-1M), "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 INSERTS

- 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)

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2.5 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.

2.6 EQUIPMENT ROOF SUPPORTS

- 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 24 inch height above top of insulation (not the roof structure).

2.7 SLEEVES

- A. Sleeves for Pipes Through Rated Floors and Walls: Schedule 40 steel pipe.
- B. Sleeves for Pipes Through Non-Rated Floors: Schedule 40 steep pipe, extended 2" above floor.
- C. Sleeves for Pipes Through Non-Rated Beams, Walls, Footings, and Potentially Wet Floors: Steel pipe or 18 gage galvanized steel, extended 2" above floor. See drawings for further detail.
- D. Sleeves for Round Ductwork: Galvanized steel, or as shown on drawings.
- E. Sleeves for Rectangular Ductwork: Galvanized steel, or as shown on drawings.

2.8 SEALANTS, FIRESTOP INSULATION, PUTTY, AND COMPOUNDS

- A. Refer to Section 07 84 13 for firestopping materials and methods. Refer to drawings for additional details.
- B. Sealants:
 - 1. Non fire/smoke rated partitions: Acrylic or silicone based caulking.
 - 2. Fire/smoke rated partitions: Silicone based caulking, UL listed.

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- C. **All fire-rated sealants and firestops shall be installed by a certified firestop contractor. Reference front-end specifications for further information.**

2.9 MECHANICAL SEALS

- A. Mechanical Seals: Modular mechanical type, consisting of interlocking low durometer 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, Link-Seal LS-316, or approved 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, Century-line Model CS, or approved 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, Century-line Model WS, 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.

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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.

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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:

<u>NPS</u>	<u>LENGTH</u>	<u>THICKNESS</u>
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.

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.

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- 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.

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- 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. Waste, vent and storm pipe penetrations through the concrete floor slab shall be encased in the poured concrete slab.
- L. Provide mechanical seals and sleeves through exterior wall and floor penetrations and 3 hour or higher fire rated partitions.

3.8 EQUIPMENT ROOF SUPPORTS

- A. Provide a minimum of two equipment roof supports for each roof-mounted equipment item that does not have integral equipment rails that would extend the bottom of the equipment a minimum of 24" above the roof insulation. Coordinate location of roof supports with equipment manufacturer.

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- B. Provide all necessary sealants and flashing required for a waterproof installation. Coordinate with roof manufacturer and other trades.

3.9 HANGER SCHEDULES

- A. Reference International Plumbing Code and International Mechanical Code where applicable.

END OF SECTION 23 05 29

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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.

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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.

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.

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- 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. Provide ceiling stickers or machine generated labels to locate valves, dampers, or HVAC equipment above T-bar type panel ceilings. Locate ceiling sticker on the ceiling grid closest to equipment. Label each sticker with the device located above the ceiling, i.e. VBR-33.
- K. 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 23 05 53

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SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING

1. GENERAL

1.1 SECTION INCLUDES

- A. Testing, adjustment, and balancing (TAB) of air systems.
- B. Measurement of final operating condition of HVAC systems.
- C. TAB of plumbing systems.

1.2 RELATED SECTIONS

- A. Drawings and general provisions of Contract, including General and Supplementary/Special Conditions and Division 1 Specifications, apply to work of this section.

1.3 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. Return air systems.
 - 3. Exhaust air systems.
 - 4. Hydronic systems.
 - 5. Steam distribution systems.
 - 6. Verify temperature control system operation.
 - 7. Plumbing water systems (i.e. recirculation pumps, booster pumps).
- C. The contractor's responsibilities are as follows:
 - 1. Notify the Owner's Representative fourteen (14) 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.

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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.

1.4 PRE-BALANCING CONFERENCE A.

- 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.

1.5 SEQUENCING AND SCHEDULING OF SERVICES

- 1.6 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.

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1.7 REFERENCES

- A. AABC - National Standards for Total System Balance.
- B. ASHRAE 111 - Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems.
- C. NEBB - Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.
- D. SMACNA - HVAC Systems Testing, Adjusting, and Balancing.

1.8 SUBMITTALS

- A. Submit name of adjusting and balancing agency for approval within 90 days after award of Contract.
- B. Field Reports: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
- C. Prior to commencing work, submit report forms or outlines indicating adjusting, balancing, and equipment data required.
- D. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect/Engineer and for inclusion in operating and maintenance manuals.
- E. Provide reports in letter size, soft cover or 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.
- F. Test Reports: Indicate data on of the following forms:
 - 1. AABC National Standards for Total System Balance forms.
 - 2. Forms prepared following ASHRAE 111.
 - 3. NEBB forms.

1.9 PROJECT RECORD DOCUMENTS

- A. Record actual locations of all sensors, flow measuring stations, balancing valves and rough setting.

1.10 QUALITY ASSURANCE

- 1. Perform total system balance in accordance with one of the following:
- 2. AABC National Standards for Field Measurement and Instrumentation, Total System Balance.
- 3. NEBB Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.

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1.11 QUALIFICATIONS

- A. Perform Work under supervision of AABC Certified Test and Balance Engineer or NEBB Certified Testing, Balancing and Adjusting Supervisor.

1.12 SEQUENCING

- A. See Section 23 05 00.
- B. Sequence work to commence after completion of systems and schedule completion of work before Substantial Completion of Project.

1.13 SCHEDULING

- A. See Section 23 05 00.

2. PRODUCTS (NOT USED)

3. EXECUTION

3.1 EXAMINATION

- A. Before commencing work and prior to convening the pre-balancing conference, the TAB agency shall coordinate with the appropriate mechanical contractors that the following conditions have been met:
 - 1. Systems are started and operating in a safe and normal condition.
 - 2. Temperature control systems are installed complete and operable.
 - 3. Proper thermal overload protection is in place for electrical equipment.
 - 4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
 - 5. Duct systems are clean of debris.
 - 6. Fans are rotating correctly.
 - 7. Fire and volume dampers are in place and open.
 - 8. Air coil fins are cleaned and combed.
 - 9. Access doors are closed and duct end caps are in place.
 - 10. Air outlets are installed and connected.
 - 11. Hydronic systems are flushed, filled, and vented.
 - 12. Pumps are rotating correctly.
 - 13. Proper strainer baskets are clean and in place.
 - 14. Service and balance valves are open.
- B. Submit field reports at the pre-balancing conference. Report ALL defects and deficiencies noted during performance of services which prevent system balance.
- C. Beginning of work means acceptance of existing conditions.

TESTING, ADJUSTING, AND BALANCING

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3.2 PREPARATION

- A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Architect/Engineer to facilitate spot checks during testing.
- B. Provide additional balancing devices as required.

3.3 INSTALLATION TOLERANCES

- A. Air Handling Systems: Adjust to within +5 to 10 percent of design for supply systems, return and exhaust systems.
- B. Air Outlets in Non-Pressurized Spaces: Adjust total to within 0 to +10 percent of design to space.
- C. Air Inlets in Non-Pressurized Spaces: Adjust total to within 0 to -10 percent of design from space.

3.4 ADJUSTING

- A. Ensure recorded data represents actual measured or observed conditions.
- B. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- C. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- D. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.5 AIR SYSTEM PROCEDURE

- A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.
- B. Make air quantity measurements in ducts by traverse of entire cross sectional area of duct.
- C. Measure air quantities at air inlets and outlets.
- D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.
- E. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by dampers.

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- F. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.
- G. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
- H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.
- I. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- J. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.
- K. For variable air volume system powered units set volume controller to air flow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable air volume temperature control.

3.6 SCHEDULES

A. Equipment Requiring Testing, Adjusting, and Balancing

- 1. All air handling units, exhaust fans, heat recovery coils, VAV boxes, heat exchangers, pumps, diffusers, registers, and grilles.

B. Report Forms

1. Title Page:

- a. Name of Testing, Adjusting, and Balancing Agency
- b. Address of Testing, Adjusting, and Balancing Agency
- c. Telephone number of Testing, Adjusting, and Balancing Agency
- d. Project name
- e. Project location
- f. Project Architect
- g. Project Engineer
- h. Project Contractor
- i. Project altitude
- j. Report date
- k. Design versus final performance
- l. Notable characteristics of system
- m. Description of systems operation sequence
- n. Summary of outdoor and exhaust flows.
- o. Nomenclature used throughout report

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- p. Test conditions
- 2. Instrument List:
 - a. Instrument
 - b. Manufacturer
 - c. Model number
 - d. Serial number
 - e. Range
 - f. Calibration date
- 3. Electric Motors:
 - a. Manufacturer
 - b. Model/Frame
 - c. HP/BHP
 - d. Phase, voltage, amperage; nameplate, actual, no load
 - e. RPM
 - f. Service factor
 - g. Starter size, rating, heater elements
 - h. Sheave Make/Size/Bore
- 4. V-Belt Drive:
 - a. Identification/location
 - b. Required driven RPM
 - c. Driven sheave, diameter and RPM
 - d. Belt, size and quantity
 - e. Motor sheave diameter and RPM
 - f. Center to center distance, maximum, minimum, and actual
- 5. Air Moving Equipment
 - a. Location
 - b. Manufacturer
 - c. Model number
 - d. Serial number
 - e. Arrangement/Class/Discharge
 - f. Air flow, specified and actual
 - g. Return air flow, specified and actual
 - h. Outside air flow, specified and actual
 - i. Total static pressure (total external), specified and actual
 - j. Inlet pressure
 - k. Discharge pressure

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- l. Sheave Make/Size/Bore
 - m. Number of Belts/Make/Size
 - n. Fan RPM
 - o. Return Air/Outside Air Data:
 - p. Identification/location
 - q. Design air flow
 - r. Actual air flow
 - s. Design return air flow
 - t. Actual return air flow
 - u. Design outside air flow
 - v. Actual outside air flow
 - w. Return air temperature
 - x. Outside air temperature
 - y. Required mixed air temperature
 - z. Actual mixed air temperature
 - aa. Design outside/return air ratio
 - bb. Actual outside/return air ratio
- 6. Exhaust Fan Data:
 - a. Location
 - b. Manufacturer
 - c. Model number
 - d. Serial number
 - e. Air flow, specified and actual
 - f. Total static pressure (total external), specified and actual
 - g. Inlet pressure
 - h. Discharge pressure
 - i. Sheave Make/Size/Bore
 - j. Number of Belts/Make/Size
 - k. Fan RPM
- 7. Duct Traverse:
 - a. System zone/branch
 - b. Duct size
 - c. Area
 - d. Design velocity
 - e. Design air flow
 - f. Test velocity
 - g. Test air flow
 - h. Duct static pressure
 - i. Air temperature
 - j. Air correction factor
- 8. Air Distribution Test Sheet:

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- a. Air terminal number
- b. Room number/location
- c. Terminal type
- d. Terminal size
- e. Area factor
- f. Design velocity
- g. Design air flow
- h. Test (final) velocity
- i. Test (final) air flow
- j. Percent of design air flow

C. Thermal Mixing Valve Test Reports: For thermal mixing valves include the following:

1. Unit Data:

- a. Unit identification.
- b. Location.
- c. Service.
- d. Make and size.
- e. Model number and serial number.
- f. Water flow rate in gpm (L/s).
- g. Water pressure differential in feet of head or psig (kPa).
- h. Recirculation pump information:
 - 1) Pump rpm.
 - 2) Impeller diameter in inches.
 - 3) Motor make and frame size.
 - 4) Motor horsepower and rpm.
 - 5) Voltage at each connection.
 - 6) Amperage for each phase.
 - 7) Full-load amperage and service factor.
 - 8) Seal type.

3.7 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 23 05 93

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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: 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. Maximum moisture absorption: less than 3 percent by volume.

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4. Density: 1.5 lb/cu ft.

B. Vapor Barrier Jacket

C. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.

1. Moisture vapor transmission: ASTM E96; 0.02 perm maximum.
2. Secure with pressure sensitive tape.

D. Vapor Barrier Tape

1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

E. Tie Wire: Annealed steel, 16 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 rubber based adhesive.

2.3 CELLULAR FOAM

A. Insulation: ASTM C534; flexible, cellular elastomeric, sheet.

1. 'K' ('ksi') Value: ASTM C177 or C518; 0.27 at 75 degrees F.
2. Minimum Service Temperature: -40 degrees F.

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3. Maximum Service Temperature: 220 degrees F.
4. Maximum Moisture Absorption: ASTM D209; 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.

- B. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.

2.4 JACKETS

- A. Aluminum Jacket: ASTM B209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.

1. Jacket: Aluminum construction, stucco embossed finish, 0.032" thick, with minimum 3-mil thick heat-bonded polyethylene and kraft paper vapor barrier.
2. Lagging Adhesive: Compatible with insulation and application.

2.5 EXTERIOR DUCT INSULATION

- A. 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. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - a. Adhesive: As recommended by jacket material manufacturer.
 - b. Color: White
 - c. PVC Jacket only required for ductwork on exterior of building.

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

DUCTWORK INSULATION

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- A. Install materials in accordance with manufacturer's instructions.
- B. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
- C. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
 - 1. Extend insulation entirely down to neck of supply air diffusers and on top of diffusers. Provide continuous vapor barrier with diffuser insulation.
- D. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
- E. Secure insulation without vapor barrier with staples, tape, or wires.
- F. 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.
- G. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
- H. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
- I. Do not overtighten and/or compress flexible glass fiber duct insulation.
- J. At duct access doors or other openings, insulation shall be properly framed and finished.
- K. On all exterior ductwork, install metal jackets with a minimum 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Secure jacket with stainless steel bands 12" o.c. and at end joints.
- L. Insulate the top of all supply air diffusers and the top/back of all supply air registers.

3.3 DUCTWORK INSULATION SCHEDULE

Ductwork Application:	Type:	Thickness:	Vapor Barrier Required (Y/N):
Exterior Ductwork	Exterior	2"	Y
Rectangular and round return air, relief air, and exhaust air duct, supply air	Flexible	2"	Y

Schedule Notes:

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- A. All ductwork in mechanical rooms shall be insulated as though it were “Exposed”.

END OF SECTION 23 07 13

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SECTION 230800 - MECHANICAL COMMISSIONING REQUIREMENTS

PART 1 GENERAL

1.1 WORK INCLUDES

- A. Validation of proper installation of Division 23 systems and equipment
- B. Systems and equipment testing and startup
- C. Equipment performance verification
- D. Functional testing of control systems
- E. Documentation of tests, procedures and installations

1.2 SCOPE INCLUDES

- A. Systems to be commissioned include the following:
 - 1. Rooftop Unit Systems
 - 2. Dedicated Outdoor Air Systems
 - 3. Exhaust Systems
 - 4. Heat Recovery System
 - 5. Variable Refrigerant Flow Systems
 - 6. Energy Management and Control Systems
 - a. Building Automation System
 - 7. Life Safety Systems
 - a. HVAC Equipment Shutdown via Fire Alarm

1.3 RELATED DOCUMENTS

- A. Commissioning Plan - This plan is part of the Contract Documents and outlines many responsibilities, procedures and tasks throughout the commissioning process.
- B. Section 019113 – General Commissioning Requirements
- C. Section 260800 – Electrical Commissioning Requirements
- D. Division 23 Sections - Individual Sections stipulate installation, startup, warranty and training requirements for the system or device specified in that Section.

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1.4 REFERENCES

- A. ASHRAE Guideline 0-2013: The HVAC Commissioning Process.
- B. ANSI/NEBB S110-2019 - Whole Building Technical Commissioning of New Construction

1.5 GENERAL DESCRIPTION

- A. Commissioning is a process to assure all building systems are installed and perform interactively according to the design intent; the systems are efficient, cost effective and meet the Owner's operational needs; the installation is adequately documented. Commissioning serves as a tool to minimize post-occupancy operational problems. It establishes testing and communication protocols in an effort to advance building systems from installation to fully optimized operation.
- B. The Commissioning Authority will work with the Contractor and Design Engineer to coordinate, oversee, and document the commissioning process during the Construction Phase of this project.
- C. This Section defines responsibilities of the Contractor to facilitate the commissioning process particularly during the Construction Phase of the project.

1.6 DEFINITIONS

- A. Refer to specification section 019113 for definitions related to the commissioning process.

1.7 DOCUMENTATION

- A. Contractor shall send Commissioning Authority one copy of the following per the procedures specified in other sections of the Specification:
 - 1. Shop drawings and product data related to systems and equipment to be commissioned on this project. CxA will review and incorporate comments via the Design Engineer.
 - 2. Initial draft of equipment startup plan checklists along with manufacturers' startup procedures. CxA will assist in development and recommend approval.
 - 3. System Test Reports. CxA will review and compile prior to FPT.
 - 4. System certificate of readiness including completed equipment startup forms along with the manufacturers' field or factory performance test documentation. CxA will review and approve prior to FPT.
 - 5. Completed Test and Balance Reports. CxA will review and approve prior to FPT.

1.8 SEQUENCING AND SCHEDULING

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- A. Systems can be in various stages of the commissioning process where appropriate, in order to expedite close out of the facility. The CxA and Contractor shall cooperate to schedule Cx tasks to minimize the duration of Cx activities. Sequential priorities shall be followed per the Cx Plan.
- B. Commissioning Schedule - Contractor shall incorporate the commissioning process into the project schedule. Startup, TAB and FPT shall be itemized as applicable for each system. Durations for each task shall be coordinated with the CxA.

1.9 COORDINATION MANAGEMENT PROTOCOLS

- A. Coordination responsibilities and management protocols relative to Cx are initially defined in the Cx Plan but will be refined and documented at the commissioning scoping meeting. Contractor shall have input to the protocols and all parties will commit to scheduling obligations. The CxA will record and distribute notes from the meeting.

1.10 CONTRACTOR RESPONSIBILITIES

- A. Construction Phase
 - 1. Include commissioning requirements in price and plan for work.
 - 2. Attend scoping and coordination meetings scheduled by the CxA.
 - 3. Remedy deficiencies identified during the construction period.
 - 4. Prepare and submit required draft forms and equipment information requested by the CxA. Typically, this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any owner-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation, start-up and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the CxA.
 - 5. Assist in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
 - 6. Provide limited assistance to the CxA in preparing the specific functional performance test procedures. Contractors shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
 - 7. Thoroughly complete and inspect installation of systems and equipment in accordance with the Contract Documents, reference or industry standards, and specifically Part 3 of this Section.

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8. Startup systems and equipment prior to verification and performance testing by the CxA. Startup procedures shall be in accordance with Contract Documents, reference or industry standards, and specifically Part 3 of this Section.
 9. Record startup and test procedures on startup forms and checklists and certify the systems and equipment have been started and tested in accordance with the Contract Documents, reference or industry standards, and specifically Part 3 of this Section. Each form shall be signed and dated by the individual responsible for the startup or test.
 10. Complete pre-approved startup checklists and submit along with other installation certification documentation such as certificate of readiness, warranties, test results, etc.
 11. Schedule and coordinate Cx efforts required by appropriate subcontractors and vendors.
 12. Demonstrate the systems as specified.
 13. Certify systems have been installed and are operating per Contract Documents through certificates of readiness.
 14. Maintain an updated set of record documentation.
 15. Copy CxA on indicated documentation.
- B. Acceptance Phase
1. Assist CxA in verification and performance testing. Assistance will generally include the following:
 - a. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
 - b. Manipulate systems and equipment to facilitate testing.
 - c. Manipulate control systems to facilitate verification and performance testing.
 2. Correct any work not in accordance with Contract Documents and non-conformances included in the commissioning issues log.
- C. Warranty Phase
1. Provide warranty service.
 2. Correct any deficiencies identified.
 3. Update record documentation to reflect any changes made throughout the Warranty Phase.

1.11 CONTROLS CONTRACTOR RESPONSIBILITIES

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- A. Sequences of Operation Submittals. The Controls Contractor's submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:
1. All interactions and interlocks with other systems.
 2. Detailed delineation of control between any packaged controls and the building automation system, listing what points the BAS monitors only and what BAS points are control points and are adjustable.
 3. Written sequences of control for packaged controlled equipment. (Equipment manufacturers' stock sequences may be included, but will generally require additional narrative).
 4. Start-up sequences.
 5. Warm-up mode sequences.
 6. Normal operating mode sequences.
 7. Unoccupied mode sequences.
 8. Shutdown sequences.
 9. Capacity control sequences and equipment staging.
 10. Temperature and pressure control: setbacks, setups, resets, etc.
 11. Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
 12. Effects of power or equipment failure with all standby component functions.
 13. Sequences for all alarms and emergency shut downs.
 14. Seasonal operational differences and recommendations.
 15. Initial and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.
 16. Schedules, if known.
 17. Include commissioning requirements in price and plan for work.
- B. Assist and cooperate with the CxA in the following manner:
1. Using a skilled technician who is familiar with this building, execute the functional testing of the controls system as specified for the controls. Assist in the functional testing of all equipment specified in Part 3 of this specification.
 2. Execute all control system trend logs specified in Part 3 of this specification.

1.12 CONTRACTOR NOTIFICATION

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- A. Contractor shall completely install, thoroughly inspect, startup, test adjust and balance systems and equipment. All activities shall be documented on specified forms. Contractor shall notify Design Engineer, Owner and CxA via the certification of readiness that systems are complete and ready for verification and functional performance testing.
- B. Contractor shall notify CxA at least 10 business days in advance of any tests or startups. CxA shall witness selected tests and startups.

1.13 STARTUP CHECKLISTS

- A. Startup checklists for each type of equipment and system shall be submitted to CxA for approval prior to startup. The forms shall be designed by the appropriate subcontractors or vendors to meet the requirements of the Contract Documents. Forms shall be developed for the specific equipment being installed for this project.
- B. Startup checklists shall generally include the following for each (as applicable):
 - 1. Project specific designation, location and service
 - 2. Pertinent nameplate data
 - 3. Indication of the party performing the test
 - 4. Field for signature of the startup technician along with the date
 - 5. Clear explanation of the observation, test, measurement, etc. with a pass/fail indication and a record of measurement parameters
 - 6. Checklist space indicating all O&M instructions, warranties, and record documents have been completed and submitted.
 - 7. Checklist space that proper maintenance clearances have been maintained
 - 8. Checklist space indicating that any required special tools and/or spare tools were turned over to the Owner
 - 9. Checklist space indicating that required prerequisite equipment and systems were successfully started.
- C. Startup checklists shall incorporate the manufacturer-specified procedures. Contractor shall compile the startup and checkout procedures indicated in the manufacturer's documentation prior to designing the forms. Include specified acceptance criteria as applicable. The manufacturer's startup and checkout procedures shall be submitted to the CxA along with the draft startup checklists.
- D. Completed startup plans for all pieces of equipment included in a system shall be submitted to CxA prior to verification and performance testing.
- E. See specification 019113 for additional information regarding Startup and Prefunctional Checklists.

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1.14 FUNCTIONAL PERFORMANCE TESTING

- A. Participation: CxA will coordinate, test and/or witness functional performance tests after the successful startup and documentation of systems and equipment is complete. Contractor shall assist, as described above, with manipulation of the systems or equipment; provision of supporting equipment or materials (lifts, ladders, specialty test equipment, etc.); and on the spot remediation of minor identified deficiencies.
- B. Detailed Test Forms: CxA will prepare detailed testing procedures and forms to conduct and document the FPT. These will be developed during the Construction Phase and completed during the Acceptance Phase.
- C. Completeness: All systems must be complete and ready for FPT. TAB work must be complete and the control systems must be tested and started for the respective system or component.
- D. Test Documentation: CxA will record test results on the forms developed for the testing. CxA will Pass or Fail the testing and record the date and time of the test. Deficiencies shall clearly indicate when the test has failed. CxA shall recommend acceptance of the system or component after all related testing is successfully complete.
- E. Deficiencies and Retesting: When deficiencies are identified during testing, depending on their extent or magnitude, they can be corrected during the test and the testing can continue to successful completion. Significant deficiencies will fail the test and require retesting of the affected portions of the test. The CxA will subsequently track the resolution of the deficiency via the Project Deficiency List. All tests shall be repeated until successful completion.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

3.1 GENERAL

- A. This Section outlines specific startup, checkout, and functional testing requirements for systems and equipment. Generally, these procedures are the direct responsibility of the Contractor as a basic element of validating that the installation is correct. These requirements along with those specified in the individual Section provide a minimum guideline for development of startup procedures, checklists and tests. Contractor shall synthesize these requirements with that of the manufacturer's and/or applicable codes and standards to develop specific and itemized startup procedures specific to that installed on this project.
- B. Refer to all Division 23 Specifications for tests performed on installed equipment and systems.

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3.2 STARTUP

- A. The HVAC mechanical and controls contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in 019113. The Contractor has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning authority or Owner.
- B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CxA, Contractor, and Owner. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all startup plan checklists as soon as possible.

3.3 VALVES – STARTUP/CHECKOUT

- A. Operate all valves, manual and automatic, through their full stroke. Ensure smooth operation through full stroke and appropriate sealing or shutoff.
- B. Verify actuators are properly installed with adequate clearance.

3.4 METERS AND GAUGES – STARTUP/CHECKOUT

- A. Adjust faces of meters and gages to proper angle for best visibility.
- B. 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. For meters and gauges requiring temporary manual connection of read-out device, such as pressure taps on a flow measuring device, ensure threads are clean and that connection can be made easily.
- C. Meters and gauges requiring manual connection of readout device shall be installed with adequate access to allow connection of device with normal tools.

3.5 MECHANICAL IDENTIFICATION – STARTUP/CHECKOUT

- A. Verify all valve tags, piping, duct and equipment labeling corresponds with drawings and indices and meets required Specifications. Correct any deficiencies for all piping and duct systems.
- B. Adjusting: Relocate any mechanical identification device that becomes visually blocked by work from this Division or other Divisions.
- C. Cleaning: Clean face of identification devices and frames of valve charts.

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3.6 MECHANICAL INSULATION – STARTUP/CHECKOUT

- A. Examine all systems and equipment that are specified to be insulated. Patch and repair all insulation damaged after installation. Ensure the integrity of vapor barrier around all cold surfaces.

3.7 PIPING – STARTUP/CHECKOUT

- A. This applies to all piping systems installed including underground site utilities.
- B. Inspect all piping for proper installation; adequate support with appropriate vibration isolation where applicable; and adequate isolation valves for required service.
- C. Flush all piping and clean all strainers.
- D. Ensure adequate drainage is provided at low points and venting is provided at high points. Ensure air is thoroughly removed from the system as applicable.
- E. Ensure all piping is adequately supported and anchored to allow expansion. Bump across the line pumps and inspect for excessive pipe movement.
- F. Pressure and/or leak test all applicable systems in accordance with requirements in Specifications, ASME B31.1, and B31.9 as applicable.
- G. Sterilize applicable piping systems as specified and as required by regulatory authorities.
- H. Submit reports that document the testing results with certification of the results.
- I. Verify the operation of safety relief valves, operating controls, safety controls, etc. to ensure a safe installation.
- J. Set and adjust fill pressure and level controls to the required setting.

3.8 AC MOTORS – STARTUP/CHECKOUT

- A. Verify proper alignment, installation and rotation.
- B. Measure insulation resistance, phase balance, and resistance to ground.
- C. Verify properly sized overloads are in place.
- D. Measure voltage available to all phases. Measure amps and RPM after motor has been placed in operation under load.
- E. Record all motor nameplate data.

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3.9 VARIABLE SPEED DRIVES – STARTUP/CHECKOUT

- A. General: Provide the services of a factory-authorized representative to test and inspect equipment installation, provide startup service and to demonstrate and train Owner's personnel.
- B. Startup Checks: Perform the following checks before startup and as specified in manufacturer's startup instructions:
 - 1. Check for shipping damage.
 - 2. Perform a point-to-point continuity test for all field installed wiring interconnections. Verify terminations of field installed wiring.
 - 3. Check for proper torque on connections.
 - 4. Verify use of shielded cable where specified and check that shields have been terminated properly.
 - 5. Verify grounding.
 - 6. Check motor nameplate against drive input rating.
 - 7. Manually rotate motor shaft to ensure free rotation.
 - 8. Check that motor leads are not grounded.
- C. Starting Procedures: Follow the manufacturer's written procedures with the following as a minimum:
 - 1. Ensure device and system which drive is serving is configured to withstand the device operation specified below.
 - 2. Adjust the minimum voltage to enable starting but not to draw excessive power at start.
 - 3. Adjust the Volts/Hz to proper setting.
 - 4. Adjust the acceleration and deceleration rates to the specified times.
 - 5. Adjust current limiting to coordinate with the overcurrent device and protect the motor.
 - 6. Set the maximum and minimum speed.
 - 7. Manually ramp fan speed from minimum to maximum and check for excessive noise and vibration.
 - 8. Determine any critical speeds to avoid and set these in the drive.
 - 9. Verify proper motor rotation in both, Normal and Bypass (if applicable) modes.
 - 10. Record the motor terminal voltage.
 - 11. Verify and document proper setup of redundant drives.
 - 12. Verify and document proper operation of bypasses.

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3.10 ROOFTOP UNITS & DOAS UNITS – STARTUP/CHECKOUT

- A. Inspect the field assembly of components and installation of rooftop units (RTU) and dedicated outdoor air systems (DOAS) including piping, ductwork and electrical connections.
- B. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum fan wheel, fan cabinet, and coils entering air face. Ensure volatile irritants are contained and kept out of occupied spaces.
- C. Adjust and lubricate dampers and linkages for proper damper operation.
- D. Ensure field fabricated unit sections are properly connected within acceptable tolerances.
- E. Seal all penetrations air tight and ensure access doors seat tightly.
- F. Verify unit is secure on mountings and supporting devices and connections for piping, ductwork and electrical are complete.
- G. Verify proper thermal overload protection is installed in motors, starters and disconnects.
- H. Ensure vibration isolation integrity and the connections to it are maintained throughout the AHU installation.
- I. Refer to AC Motors in this Section.
- J. Disconnect fan drive from motor and verify proper motor rotation direction; verify fan wheel free rotation; and verify smooth bearing operations. Reconnect fan drive system, align belts and install belt guards. Rotation shall be checked with VFD operating in normal and bypass modes (if applicable).
- K. Lubricate bearings, pulleys, belts and other moving parts with factory-recommended lubricants.
- L. Comb coil fins for parallel orientation.
- M. Install clean filters.
- N. Ensure condensate drains properly and trap is adequate.
- O. Stroke all valves and dampers to ensure free and full travel.
- P. Pressure test units as required in the Specification.
- Q. Refer to Section 230990 Testing, Adjusting, and Balancing for detailed requirements for testing, adjusting, and balancing air handling systems.
- R. Refer to Section 230900 HVAC Instrumentation and Controls for detailed requirements for starting the controls related to the air handling systems.

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3.11 VARIABLE REFRIGERANT VOLUME SYSTEM – STARTUP/CHECKOUT

- A. Inspect the field assembly of components and installation of variable refrigerant volume (VRF) systems including piping, ductwork and electrical connections.
- B. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum fan wheel, fan cabinet, and coils entering air face. Ensure volatile irritants are contained and kept out of occupied spaces.
- C. Adjust and lubricate dampers and linkages for proper damper operation.
- D. Ensure field fabricated unit sections are properly connected within acceptable tolerances.
- E. Seal all penetrations air tight and ensure access doors seat tightly.
- F. Verify unit is secure on mountings and supporting devices and connections for piping, ductwork and electrical are complete.
- G. Verify proper thermal overload protection is installed in motors, starters and disconnects.
- H. Ensure vibration isolation integrity and the connections to it are maintained throughout the VRF installation.
- I. Refer to AC Motors in this Section.
- J. Disconnect fan drive from motor and verify proper motor rotation direction; verify fan wheel free rotation; and verify smooth bearing operations. Reconnect fan drive system, align belts and install belt guards. Rotation shall be checked with VFD operating in normal and bypass modes (if applicable).
- K. Lubricate bearings, pulleys, belts and other moving parts with factory-recommended lubricants.
- L. Comb coil fins for parallel orientation.
- M. Install clean filters.
- N. Ensure condensate drains properly and trap is adequate.
- O. Stroke all valves and dampers to ensure free and full travel.
- P. Pressure test units as required in the Specification.
- Q. Refer to Section 230990 Testing, Adjusting, and Balancing for detailed requirements for testing, adjusting, and balancing air handling systems.
- R. Refer to Section 230900 HVAC Instrumentation and Controls for detailed requirements for starting the controls related to the air handling systems.

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3.12 FANS – STARTUP/CHECKOUT

- A. Inspect the field assembly of components and installation of fans including ductwork and electrical connections.
- B. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum fan wheel, fan cabinet and coils entering air face. Ensure volatile irritants are contained and kept out of occupied spaces.
- C. Adjust and lubricate dampers and linkages for proper damper operation.
- D. Verify unit is secure on mountings and supporting devices and connections for ductwork and electrical are complete.
- E. Verify proper thermal overload protection is installed in motors, starters and disconnects.
- F. Ensure vibration isolation integrity and the connections to it are maintained with the fan installation.
- G. Refer to AC Motors in this Section.
- H. Disconnect fan drive from motor and verify proper motor rotation direction; verify fan wheel free rotation; and verify smooth bearing operations. Reconnect fan drive system, align belts and install belt guards. Rotation shall be checked with VFD operating in normal and bypass modes (if applicable).
- I. Lubricate bearings, pulleys, belts and other moving parts with factory-recommended lubricants.
- J. Stroke all dampers to ensure free and full travel.
- K. Refer to Section 230990 Testing, Adjusting, and Balancing for detailed requirements for testing, adjusting, and balancing fans.
- L. Refer to Section 230900 HVAC Instrumentation and Controls for detailed requirements for starting the controls related to the fans.

3.13 METAL DUCTWORK – STARTUP/CHECKOUT

- A. Leakage Tests: Refer to Section 233113 Ductwork for duct testing requirements.
- B. Clean ductwork internally of dust and debris unit by unit as it is installed. Clean external surfaces of foreign substances, which might cause corrosive deterioration of metal or where ductwork is to be painted might interfere with painting or cause paint deterioration.
- C. Strip protective paper from stainless ductwork surfaces and repair finish wherever it has been damaged.

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- D. Temporary Closure: Provide temporary closure at ends of ducts, which are not connected to equipment or air distribution devices at time of ductwork installation. Use polyethylene film or other covering that will prevent entrance of dust and debris until connections are completed.
- E. Balancing: Refer to Section 230990 Testing, Adjusting, and Balancing for air distribution balancing of metal ductwork. Seal any leaks in ductwork that become apparent in balancing process.

3.14 DUCTWORK ACCESSORIES – STARTUP/CHECKOUT

- A. Operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories as required to obtain proper operation and leak proof performance.
 - 1. Adjusting: Adjust ductwork accessories for proper settings. Install fusible links in fire dampers and adjust for proper action.
 - 2. Label access doors in accordance with Division 23 specification sections.
 - 3. Mark final positioning of manual dampers as specified in Section 230990 Testing, Adjusting, and Balancing.
- B. Fire Damper Testing: For every fire damper, remove the fusible link and verify the damper operates freely and closes tightly. Reinstall the fusible link.
- C. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.15 CONTROL SYSTEMS – STARTUP/CHECKOUT

- A. Startup: Refer to Section 230900 HVAC Instrumentation and Controls. This Specification generally requires manufacturer's authorized representative to startup, test, adjust and calibrate DDC control systems and demonstrate compliance with requirements. This includes verification of sequences, normal and emergency operations, calibration, interfaces, interlocks, etc.
- B. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.16 FUNCTIONAL TESTING

- A. This section specifies the functional testing requirements for Division 23 systems and equipment. From these requirements, the Commissioning Authority (CxA) shall develop step-by-step procedures to be executed by the Contractors. The general functional testing process, requirements and test method definitions are described in Section 019113. The test requirements for each piece of equipment or system contain the following:

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1. The contractors responsible to execute the tests, under the direction of the CxA
2. A list of the integral components being tested
3. Startup plan checklists associated with the components
4. Functions and modes to be tested
5. Required conditions of the test for each mode
6. Special procedures
7. Required methods of testing
8. Required monitoring
9. Acceptance criteria
10. Sampling strategies allowed

B. PREREQUISITES

The following applicable generic prerequisite checklist items are required to be completed and submitted with the equipment/system certificate of readiness and checked off by CxA prior to functional testing.

1. All related equipment has been started up and startup plan checklists submitted and approved ready for functional testing.
2. All control system functions for this and all interlocking systems are programmed and operable per contract documents, including final setpoints and schedules with debugging, loop tuning and sensor calibrations completed.
3. Piping system flushing complete and required report approved
4. Water treatment system complete and operational
5. Test and balance (TAB) complete and approved for the air and hydronic systems
6. All A/E punchlist items for this equipment corrected
7. Schedules and setpoints provided to the CxA
8. False loading equipment, system and procedures ready.
9. Sufficient clearance around equipment for servicing

C. MONITORING

1. Monitoring is a method of testing as a stand-alone method or to augment manual testing.
2. All points listed in the required monitoring section of the test requirements which are control system monitored points shall be trended by the controls contractor. Other points shall be monitored by the CxA using dataloggers. At the option of the CxA, some control system monitoring may be replaced with datalogger monitoring. At the CxA's request, the controls contractor shall trend up to 20% more points than listed herein at no extra charge.

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3. Trend output data must be in a spreadsheet file (Excel or similar) with time continuous down left column and point values in column(s) to the right.
4. All trends for points of a group must start at the same moment in time, unless specifically approved otherwise with the commissioning agent.

3.17 ROOFTOP UNITS (RTU) & DEDICATED OUTDOOR AIR UNITS (DOAS) FPT

- A. Parties Responsible to Execute Functional Test
 1. Controls contractor: operate the controls to activate the equipment as needed.
 2. HVAC mechanical contractor or vendor: assist in testing sequences as needed.
 3. Electrical contractor: perform loss of power testing
 4. Fire alarm contractor: assist in testing sequences as needed.
 5. CxA: to witness, direct and document testing.
- B. Integral Components or Related Equipment Being Tested
 1. Unit and components (fans, coils, valves, humidifiers, ducts, VFD)
 2. Heat recovery coil, humidifier or evaporative cooling sections
- C. Prerequisites: The applicable prerequisite checklist items listed in paragraph 3.20.B shall be listed on each certificate of readiness form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the startup plan checklists previously completed by the installer, before the beginning of functional testing.
- D. Functions / Modes Required to Be Tested, Test Methods and Seasonal Test Requirements: The following testing requirements are an addition to and do not replace any testing requirements elsewhere in this Division.

<u>Function / Mode</u>	<u>Test Method</u> Manual, Monitoring, Either or Both ³	<u>Required</u> <u>Seasonal</u> <u>Test</u> ¹
General 1. Test each sequence in the sequence of operations, and other significant modes and sequences not mentioned; including startup, shutdown, unoccupied & manual modes and power failure. Test functionality of this piece of equipment or system in all control strategies or interlocks with which it is associated.	Manual	
In addition to, or as part of (1) above, the following modes or tests are required:		
2. Supply air & reset temperature control functions.	Both	Both
3. SF and exhaust fan interlocks.	Either	
4. No Cooling when there is Heating	Both	

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Function / Mode	Test Method Manual, Monitoring, Either or Both ³	Required Seasonal Test ¹
5. Duct static pressure (SP) control.	Both	
6. Exhaust fan tracking and building SP.	Monitoring	Both
7. VFD operation on SF: modulation to minimum, control system PID, constancy of static pressure, verification of program settings, alarms, etc.	Both	²
8. Damper interlocks and correct modulation in all modes	Manual	
9. Temperature difference across HC & CC per specifications.	Manual	
10. Heating and cooling coils freeze protection.	Manual	²
11. Night low limit, morning warmup cycle.	Either	Both
12. Heat recovery operation.	Monitoring	Both
13. Verify TAB reported SF cfm with control system reading.	Manual	²
14. All alarms (low limits, high static, etc.).	Manual	
15. Sensor and actuator calibration checks: Duct static pressure sensor, SAT, MAT, OSAT, OSA & RA damper and valve positions, SF cfm reading with TAB, and other random checks (BAS readout against hand-held calibrated instrument or observation must be within specified tolerances)	Manual	
16. Verify schedules and setpoints to be reasonable, appropriate, and coordinated with the Owner's Project Requirements.		

¹Design cooling season, heating season or both. "Design" means within 5° of season design or 95% of loading design. A blank cell denotes no special seasonal test is required and that test can be executed during any season, if condition simulation is appropriate.

²Seasonal test not required if seasonal conditions can be adequately simulated.

³Refer to Special Procedures

E. Special Procedures or Conditions

- None

F. Required Monitoring

- All points listed below that are control system monitored points shall be trended by the controls contractor. Other points shall be monitored by the CxA using dataloggers. Refer to the Monitoring section at paragraph 3.20.C for additional monitoring details.

Point	Time Step (min.)	Minimum Time Period of Trend
For each AHU being tested:		
OAT / RAT	10	7 days
SAT and SAT setpoint	10	7 days
PHC / CC / HC LAT	10	7 days
SF speed, if variable, else status	10	7 days
EF speed, if variable, else status	10	7 days

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Duct SP and SP setpoint	10	7 days
Building / Space differential pressures	10	7 days
PHV / CCV / HCV / HUV position	10	7 days
Space temperature	10	7 days
Space relative humidity	10	7 days
SA relative humidity	10	7 days

G. Acceptance Criteria

1. For the conditions, sequences and modes tested, the AHU, integral components, and related equipment respond to varying loads and changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.
2. AHU with supporting systems shall be able to maintain the SA temperature within 1.0°F of either side of the deadband of the current setpoint without excessive hunting.
3. AHU and controls shall control the duct static pressure/airflow so that it does not drift more than an amount equal to 10% of the setpoint value to either side of the deadband without excessive hunting.
4. Space temperatures shall average within +/- 1°F of setpoint and always remain within 1°F of the ends of the deadband without excessive hunting of coil valve/heating demand, or complaints of drafts or stuffiness from occupants.
5. Space relative humidity shall average between +/- 5% RH of seasonal setpoint.
6. AHU system and controls shall maintain the space temperature and humidity within the parameters defined in the Contract Documents.

END OF REQUIREMENTS FOR AHU TEST

3.18 EXHAUST FANS FPT

A. Parties Responsible to Execute Functional Test

1. Controls contractor: operate the controls to activate the equipment, if BAS controlled.
2. HVAC mechanical contractor or vendor: assist in testing sequences.
3. CxA: to witness, direct and document testing.

B. Integral Components or Related Equipment Being Tested

1. Exhaust fans

C. Prerequisites: The applicable prerequisite checklist items listed in paragraph 3.20.B shall be listed on each certificate of readiness form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the startup

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plan checklists previously completed by the installer, before the beginning of functional testing.

- D. Functions / Modes Required to Be Tested, Test Methods and Seasonal Test Requirements: The following testing requirements are an addition to and do not replace any testing requirements elsewhere in this Division.

<u>Function / Mode</u>	<u>Test Method</u> Manual, Monitoring, Either or Both ¹	<u>Required</u> <u>Seasonal</u> <u>Test</u>
General		
1. Test each sequence in the sequence of operations, and other significant modes and sequences not mentioned; including startup, shutdown, unoccupied & manual modes and power failure. Test functionality of this piece of equipment or system in all control strategies or interlocks that it is associated with.	Manual	
In addition to, or as part of (1) above, the following modes or tests are required:		
2. Verify schedules and setpoints to be reasonable, appropriate, and coordinated with the Owner's Project Requirements		
3. Function at fire alarm (off, depressurization, etc.)	Manual	
4. Interlocks to building pressurization control	Manual	
5. Speed controls	Either	
6. Sensor calibration checks on any controlling temperature or pressure sensor	Manual	

¹Refer to Special Procedures

- E. Special Procedures or Conditions

1. None

- F. Required Monitoring

1. All points listed below which are control system monitored points shall be trended by the controls contractor. Other points shall be monitored by the CxA using dataloggers. Refer to the Monitoring section at paragraph 3.20.C for additional monitoring details

Point	Time Step (min.)	Minimum Time Period of Trend
For each fan:		
EF speed, if variable, else status	10	7 days
Space/building pressure	10	7 days
Space temperature (if applicable)	10	7 days

- G. Acceptance Criteria

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1. For the conditions, sequences and modes tested, the fans, integral components and related equipment respond to changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.

END OF REQUIREMENTS FOR EXHAUST FAN TEST

3.19 VARIABLE REFRIGERANT VOLUME UNITS FPT

A. Parties Responsible to Execute Functional Test

1. Controls contractor: operate the controls to activate the equipment.
2. HVAC mechanical contractor or vendor: assist in testing sequences.
3. CxA: to witness, direct and document testing.

B. Integral Components or Related Equipment Being Tested

1. Terminal unit (AC/CU)

C. Prerequisites: The applicable prerequisite checklist items listed in paragraph 3.20.B shall be listed on each certificate of readiness form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the startup plan checklists previously completed by the installer, before the beginning of functional testing.

D. Functions / Modes Required to Be Tested, Test Methods and Seasonal Test Requirements: The following testing requirements are an addition to and do not replace any testing requirements elsewhere in this Division.

<u>Function / Mode</u>	<u>Test Method</u> Manual, Monitoring, Either or Both ³	<u>Required</u> <u>Seasonal</u> <u>Test</u> ¹
General		
1. Test each sequence in the sequence of operations, and other significant modes and sequences not mentioned; including startup, warmup, shutdown, unoccupied & manual modes and power failure and restoration. Test functionality of this piece of equipment or system in all control strategies or interlocks that it is associated with, including all damper, valve and fan functions.	Manual	
In addition to, or as part of (1) above, the following modes or tests are required:		
2. Sensor activator calibration checks on: AC DAT, zone air temperature, damper position and other random checks (BAS readout against visual or hand-held calibrated instrument must be within 0.5°F for temps. or within a tolerance equal to 10% of static pressure setpoint)	Manual	

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3.	Verify control parameters and setpoints to be reasonable and appropriate by reviewing the full program of all the TU's with each other for consistency. Verify the max. and min. cfm setpoints of all ACs against the control drawing and TAB values.	Observation	
4.	Verify no hunting or significant overshoot by damper or valves.	Either	
5.	All alarms (fan status, low limits, high static, etc.)	Manual	
6.	Verify that AC is maintaining space setpoint temperatures	Monitoring	Both Design

¹Design cooling season, heating season or both. "Design" means within 5°F of season design or 95% of loading design. A blank cell denotes no special seasonal test is required and that test can be executed during any season, if condition simulation is appropriate.

²Seasonal test not required if seasonal conditions can be adequately simulated.

³Refer to Special Procedures

E. Special Procedures or Conditions

1. None

F. Required Monitoring

1. All points listed below which are control system monitored points shall be trended by the controls contractor. Other points shall be monitored by the CxA using dataloggers. Refer to the Monitoring section at paragraph 3.20.C for additional monitoring details

Point	Time Step (min.)	Minimum Time Period of Trend
For each zone thermostat and space sensor and other critical areas, monitor:		
Space temperature (summer design)	10	7 days
Space temperature (winter design)	10	7 days
Heating coil valve/heating command	10	7 days
Damper position and cfm	10	7 days

G. Acceptance Criteria

1. For the conditions, sequences and modes tested, the TU, integral components and related equipment respond to varying loads and changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.
2. Space temperature during occupied modes shall average within +/- 1°F of setpoint and always remain within 1°F of the ends of the deadband without excessive hunting of either the damper or coil valve/heating demand, or complaints of drafts or stuffiness from occupants.

END OF REQUIREMENTS FOR TERMINAL UNIT TEST

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3.20 TEST AND BALANCE WORK (TAB)

- A. Parties Responsible to Execute Functional Test
 - 1. TAB contractor: perform checks using test instruments.
 - 2. Controls contractor: operate the controls to activate the equipment.
 - 3. CxA: to witness, direct and document testing.
- B. Integral Components or Related Equipment Being Tested
 - 1. TAB air-side
- C. Prerequisites: The applicable prerequisite checklist items listed in paragraph 3.20.B shall be listed on each certificate of readiness form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the startup plan checklists previously completed by the installer, before the beginning of functional testing.
- D. Purpose. The purpose of this test is to spot check the TAB work to verify that it was done in accordance with the contract documents and acceptable practice and that the TAB report is accurate.
- E. The following tests and checks will be conducted. The following testing requirements are in addition to and do not replace any testing requirements elsewhere in this Division.

Test or Check	Test Method
1. A random sample of up to 10% the TAB report data shall be selected for verification (air velocity, air or water flow rate, pressure differential, electrical measurement, etc.). The original TAB contractor will execute the checks, witnessed by the commissioning authority. The TAB contractor will use the same test instruments as used in the original TAB work. A failure ¹ of more than 10% of the selected items of a given system ² shall result in the failure of acceptance of the system TAB report and the TAB contractor shall be responsible to rebalance the system in its entirety, provide a new system TAB report and repeat random verifications of the new TAB report.	Demonstration
2. Verify that final settings of all valves, dampers and other adjustment devices have been permanently marked by the TAB Contractor.	Demonstration
3. Verify that the air system is being controlled to the lowest possible static pressure while still meeting design loads, less diversity. This shall include a review of TAB methods, control setpoints established by TAB and a physical verification of at least one leg from fan to diffuser having all balancing dampers wide open and that during full cooling of all TUs taking off downstream of the static pressure sensor, the TU on the critical leg has its damper 90% or more open.	Demonstration

¹Failure of an item is defined as follows:

For air flow of supply and return: a deviation of more than 10% of instrument reading

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For minimum outside air flow: 20% of instrument reading
For temperatures: a deviation of more than 1°F
For air and water pressures: a deviation of more than 10% of full scale of test instrument reading

²Examples of a “system” are: the air distribution system served by one air handler or the hydronic chilled water supply system served by a chiller or the condenser water system. Systems can be defined as smaller parts if inaccuracies in TAB work within the smaller defined system will have little or no impact on connected systems.

F. Special Procedures or Conditions

1. Rechecking shall be limited to either 10% of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

G. Required Monitoring

1. None

H. Acceptance Criteria

1. Provided in footnote to test table above.

END OF REQUIREMENTS FOR TAB TEST

END OF SECTION 230800

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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:

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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. 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.
1. Automatic Balance Valves:

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- 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.
- B. 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.
- C. 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.
- D. 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.

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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/°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 °F to 130 °F.
 - (b) Tower Water: 30 °F to 130 °F.
 - (c) Hot Water: 100 °F to 250 °F.
 - (d) Steam: 150 °F to 450 °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 °F, whichever is greater.
 - (7) Supply Voltage: 24 VDC.
 - (8) Ambient Operating Temp.: 32 to 122 °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.

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- (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 $\pm 2\%$ 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.

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- 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.

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- 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 1/4" 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

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- 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.

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- (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.
- T. Magnetic Flowmeter for Chilled Water, Tower Water, Make Up Water:
 - 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 Chilled Water flow, Cooling Tower Water flow, or Make Up 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:

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- 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° or 45° 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 °F
 - l) Flow Tube Process Temp.: 32 °F to 140 °F for Chilled Water applications
 - m) Flow Tube Process Temp.: 32 °F to 140 °F for Make Up Water applications
 - n) Flow Tube Process Temp.: 32 °F to 311 °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 °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.

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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 years.

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, described 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, described as 22-03 OAS STR PLNM NEON BLU JK distributed by Windy City Wire, constructed by Cable-Tek, or approved equivalent.

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- 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.

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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

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- 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

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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 23 00 - REFRIGERANT PIPING AND SPECIALTIES

1. GENERAL

1.1 SECTION INCLUDES

- A. Piping.
- B. Refrigerant.

1.2 RELATED SECTIONS

- A. Section 23 05 00 – Basic HVAC Requirements
- B. Section 23 05 29 – HVAC Hangers and Supports
- C. Section 22 07 00 – Piping Insulation

1.3 REFERENCES

- A. Reference Section 23 05 00.

1.4 SYSTEM DESCRIPTION

- A. Where more than one piping system material is specified ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
- B. Provide pipe hangers and supports in accordance with ASTM B31.5 and MSS SP69 unless indicated otherwise.
- C. The Mechanical Contractor to make necessary provisions in their bid for different VRF manufacturers. Each VRF manufacturer may require a different size, length, or amount of refrigerant piping corresponding to their system design. The mechanical contractor shall coordinate this with the selected VRF manufacturer.

1.5 SUBMITTALS

- A. Reference Section 23 05 00.

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1.6 OPERATION AND MAINTENANCE DATA

- A. Reference Section 23 05 00.

1.7 QUALIFICATIONS

- A. Reference Section 23 05 00.

1.8 REGULATORY REQUIREMENTS

- A. Welding Materials and Procedures: Conform to ASME SEC 9 and applicable state and local labor regulations.
- B. Welders Certification: In accordance with ASME SEC 9. and AWS D1.1.
- C. Products Requiring Electrical Connection: Listed and classified by UL, as suitable for the purpose indicated.

1.9 DELIVERY, STORAGE AND HANDLING

- A. Reference Section 23 05 00.

2. PRODUCTS

2.1 PIPING

- A. Copper Tubing: ASTM B280, Type ACR hard drawn. Tubing shall be factory cleaned, ready for installation and have ends capped to protect cleanliness of pipe interiors prior to shipping. At the contractors option pre-insulated refrigerant line set may be used on refrigerant suction pipes.
 - 1. Fittings: ACR drawn fittings..
 - 2. Joints: Braze, sil//fos or Phosco. Minimum 15% silver bearing filler material shall be used.
 - 3. Copper Tubing to 7/8 inch OD: ASTM B88, Type K, hard drawn.
 - 4. Fittings: ASME B16.26 cast copper.
 - 5. Pipe Supports and Anchors: Provide in accordance to Section 23 05 29 HVAC Hangers and Supports.
- B. At the Contractor's option, ASTM B210 complying to ASME B31.5, seamless aluminum tubing 6061, 0.025" to 0.50" wall thickness, T4 temper, 8.5 KSI maximum allowable stress may be substituted. If aluminum tubing is substituted, the joints must be made without the use of heat. Any joint fitting must be UL or ETL listed and tested per UL-207 for joining refrigeration tubing using either copper or aluminum tubing. Install per manufacturer's recommended installation instructions.

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1. Fittings: ACR Reflok Fittings, ASTM B210 seamless drawn aluminum tubing, cleaned and capped in accordance with ASTM B280, and complying with ASME B31.5, with Reflock steel fittings. The fitting or coupling joins metal refrigeration tubing such as copper, aluminum, titanium, or steel by means of a permanent mechanical compression seal.
2. ETL tested and listed to UL 207 Reflok fittings for joining copper to copper, aluminum to aluminum or aluminum to copper. Fittings shall have dielectric coating to allow connection of dissimilar metals and prevent galvanic corrosion. Fittings shall be certified to a working pressure of 600 psi.

C. Rektekk Bendable Copper Piping System

2.2 REFRIGERANT

- A. Refrigerant: R-410A per ASHRAE 34. Coordinate exact refrigerant with split system manufacturer.

2.3 CELLULAR FOAM INSULATION

- 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: Air dried, contact adhesive, compatible with insulation.

3. EXECUTION

3.1 PREPARATION

- A. Ream pipe and tube ends. Remove burrs.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

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3.2 INSTALLATION

- A. Install refrigeration piping sizes and specialties in accordance with manufacturer's recommendations and instructions for actual installation.
- B. Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.
- C. Install piping to conserve building space and not interfere with use of space.
- D. Group piping whenever practical at common elevations and locations. Slope piping per manufacturer's recommendations.
- E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- F. Pipe Hangers and Supports:
 - 1. Install in accordance with Section 23 05 29 HVAC Hangers and Supports.
- G. Provide traps and loops in piping as recommended by the refrigeration manufacturer.
- H. **Flood piping system with nitrogen when brazing.**
- I. Insulate piping; refer to Section 22 07 00.

3.3 COMMISSIONING

- A. Follow ASHRAE 15 and manufacturer procedures for charging and purging of systems and for disposal of refrigerant.
- B. Fully charge completed system with refrigerant after testing.

3.4 FIELD QUALITY CONTROL

- A. Field inspect and test refrigerant system.
- B. Test refrigeration system in accordance with ASME B31.5.
- C. Pressure test system with dry nitrogen to 200 psig. Perform final tests at 27 inches vacuum and 200 psig using halide torch or electronic leak detector. Test to no leakage.

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- D. After final connections evacuate to 500 microns and allow pump to operate for an additional 15 minutes. Break vacuum with dry nitrogen and test to no leakage for minimum period of one hour. If leaks are found they shall be repaired by melting the joint, removing the fitting, thoroughly cleaning both pipe and fitting, and resoldering joint. Repeat leak test procedure until system is leak free. Evacuate system to 500 microns and charge with refrigerant. Owner representative shall be present to observe joining and purge procedures and leak test.
- E. Provide factory authorized start-up and pressure testing witness services by equipment manufacturer's factory authorized service technicians.

3.5 CLEANING

- A. Before installation of copper tubing other than Type ACR tubing, clean the tubing and fitting using following cleaning procedure:
 - 1. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through the tubing by means of a wire or an electrician's tape.
 - 2. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
 - 3. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
 - 4. Finally, draw a clean, dry, lintless cloth through the tube or pipe.

END OF SECTION 23 23 00

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SECTION 23 31 13 - DUCTWORK

1. GENERAL

1.1 SECTION INCLUDES

- A. Metal ductwork.
- B. Pre-insulated HVAC ductwork
- C. Duct cleaning.
- D. Sheet metal plenums.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

- A. References.
- B. Performance requirements.

1. No variation of duct configuration or sizes shall be permitted except by written permission.

C. Submittals.

1. Submit detailed CAD-generated ductwork drawings at minimum 1/4" 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. Project record documents.

- 1. Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

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E. 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. NFPA 91 - Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying.
 - d. SMACNA - HVAC Air Duct Leakage Test Manual.
 - e. SMACNA – HVAC Duct Construction Standards - Metal and Flexible.
 - f. SMACNA - Round Industrial Duct Construction Standards
 - g. International Mechanical Code, current edition.

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

1.3 Environmental requirements.

- A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
- B. Maintain temperatures during and after installation of duct sealants.

2. PRODUCTS

2.1 MATERIALS

- A. 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.
- B. 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 concealed ducts.
- C. Insulated Flexible Ducts:

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1. UL 181, Class 1, mechanically-locked spun nylon fabric supported by helically wound spring steel wire; fiberglass insulation; fire retardant polyethylene vapor barrier film.
 2. Pressure Rating: 6 inches WG positive, 5.0 inches WG negative (through 16" diameter), 1.0' WG negative (18" to 20").
 3. Maximum Velocity: 5500 fpm.
 4. Temperature Range: -20 degrees F to 250 degrees F.
 5. Minimum Sound Attenuation Performance (Insertion Loss in dB of 12' Length of 12" Round Duct):
 - a. 63 Hz Octave Band: 13
 - b. 125 Hz Octave Band: 37
 - c. 250 Hz Octave Band: 31
 - d. 500 Hz Octave Band: 34
 - e. 1 kHz Octave Band: 37
 - f. 2 kHz Octave Band: 47
 - g. 4 kHz Octave Band: 34
 6. Manufacturer: Flexmaster Type 6B or equivalent.
- D. Fasteners: Rivets, bolts, or sheet metal screws.
- E. Sealant: ASTM E84 and UL rated, NFPA 90A and 90B approved, Non-hardening, water resistant, fire resistive, compatible with mating materials; and rated for all pressure duct systems. Fabric and metal backed duct tapes are not acceptable.
- F. Hanger Rod: ASTM A36; steel or galvanized, threaded.

2.2 SHOP FABRICATED DUCTWORK

- A. Fabricate, reinforce and support in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, latest edition, and as indicated. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- B. Construct T's, and elbows in accordance with SMACNA HVAC Duct Construction Standards-Metal and Flexible, latest edition, using radius of not less than 1-1/2 times width of duct on centerline. Where mitered rectangular elbows are used or indicated, provide dual wall airfoil turning vanes.
- C. Reference SMACNA figure 2-9 to construct gradual transitions where ductwork changes size or offsets.

2.3 MANUFACTURER FABRICATED DUCTWORK

- A. Fabricate, reinforce and support in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, latest edition, and as indicated. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.

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- B. Round and oval duct shall be spiral lockseam duct with light reinforcing corrugations unless indicated otherwise.
- C. 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 double wall airfoil turning vanes.
- D. Fabricate round and oval duct; fittings in accordance with SMACNA Standards. Joints shall be minimum 2 inch insertion length for joint connections.
- E. Weld 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.
- F. 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.

2.4 TRANSVERSE DUCT CONNECTION SYSTEM – RECTANGULAR DUCT

- A. 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.
- B. 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).

2.5 TRANSVERSE DUCT CONNECTION SYSTEM – ROUND AND OVAL DUCT

- A. Slip type connector: Keating coupler.
- B. 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.
- C. Formed on flange system: Factory-applied Van Stone connection on one end of the duct with field-applied Van Stone connector on the other end of the duct. Provide factory-applied Van Stone connections on each end of fittings.

2.6 PRE-INSULATED HVAC DUCTWORK SYSTEM

- A. Pre-Insulated HVAC Ductwork System: Provide Kingspan KoolDuct System or equivalent for supply, return, fresh, and exhaust air ductwork as shown on the Drawings. System shall include panels, fabrication methods, coupling systems, and accessories to provide a complete system to meet the following performance criteria:

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1. Classification: UL Listed as a Class 1 Air Duct, to UL 181, NFPA 90A and NFPA 90B
2. Fire and Smoke Performance when tested in accordance with ASTM E84 or UL 723:
 - a. Flame Spread: ≤ 25
 - b. Smoke Developed: ≤ 50
3. Materials: CFC/HCFC free, zero Ozone Depletion Potential (ODP), fiber-free rigid thermoset phenolic insulation core faced with 1 mil low vapor permeability aluminum foil reinforced with glass scrim. Foil is branded on inside of duct and plain on the outer facing.
4. Nominal Density: 3.4 to 3.75 pcf (55 to 60 kg/m³).
5. Closed Cell Content: minimum 90 percent
6. Compressive Strength: Minimum 29 psi (200 kPa) at 10 percent compression.
7. Air Leakage: SMACNA Air Leakage Class 3.
8. Mean Air Velocity: Maximum 5000 fpm (25.4 m/s) with all joints sealed.
9. Design Pressures:
 - a. Positive Pressure: Maximum 4 inch w.g. (1000 Pa).
 - b. Negative Pressure: Maximum 3 inch w.g. (750 Pa).
10. Commissioning Pressures - As designed to, max commissioning 4 inch w.g. (1000Pa.).
11. Temperature Range: Internal air temperature range -15 to 185 deg. F (-26 to 85 C) during
12. Thermal Resistance, Wall Thickness and R-Value:
 - a. 1-25/32 inch (45mm) thick, R 12 square feet per hour F/Btu
13. Thermal Conductivity: at 50 to 74 deg. F (10 to 23 deg C), mean 0.146 Btu inch per square foot per hour deg. F (0.021 W/m K) per ASTM C518.
14. Typical Configuration: Rectangular.

B. ACCESSORIES

- C. Fittings: In accordance with SMACNA Phenolic Duct Construction Standards or the ASHRAE Design Fundamentals Handbook Chapter 35 or the SMACNA HVAC Duct Systems Design Manual.

D. Support Systems:

1. Tiger Support and Wire Hanger Assembly.
2. Steel Channel Support and Threaded Rods.

E. Coupling Systems:

1. Tiger Clip Coupling System.
2. Aluminum Grip Coupling System.
3. 4-Bolt Coupling System.

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F. Plenum Boxes:

1. Lightweight and easy to install.
2. For use with either pre-insulated duct or sheet metal systems.

G. Dampers:

1. Volume Control Dampers.
2. Fire Dampers.

H. Access Doors:

1. Metal insulated access doors.
2. Fabricated from the Kingspan KoolDuct System including the same insulation system, and to ensure a continuous vapor barrier.

I. Turning Vanes.

J. Reinforcement Systems.

K. Tools.

L. V-Groove sealant: Silicone with VOC content of 250 g/L or less.

M. Tape: Comply with UL 181A.

1. Product: Pressure-sensitive aluminum foil tape imprinted with manufacturer with UL markings, manufacturer name, and date.
2. Minimum Width: 3 inch (75 mm).
3. Water, mold, and mildew resistant.
4. .

N. Self-Adhesive Gaskets.

O. Closures and Flanges.

P. FABRICATION

Q. Fabricate ductwork with panels, joints, seams, transitions, reinforcements, supports, elbows, connections, and accessories in accordance with SMACNA Phenolic Duct Construction Standards and the manufacturers' guidelines.

1. 90 degree mitered elbows shall include turning vanes.

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R. Fabricate ductwork with branded foil facing consistently inside the duct system.

S. FINISH

T. Standard Finish: Factory-applied aluminum foil vapor barrier facing.

3. EXECUTION

3.1 INSTALLATION

- 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. Drawings indicate general arrangement of ducts, fittings, and accessories.
- D. Support exterior ductwork routed vertically up the building with painted steel, aluminum or stainless steel wall bracket supports as required.
- E. Construct and install each duct system for the specific duct pressure classification indicated.
- F. Install round in lengths not less than 12 feet, unless interrupted by fittings.
- G. Install ducts with fewest possible joints.
- H. Install fabricated fittings for changes in directions, changes in size and shape, and connections.
- I. Install only low loss high efficiency fittings at takeoffs. Extractors not allowed.
- J. Install couplings tight to duct wall surface with a minimum of projections into duct.
- K. Install ducts, unless otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs.
- L. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- M. Install ducts with a clearance of 2 inch, plus allowance for insulation thickness.
- N. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions, unless specifically indicated.

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- O. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.
- P. Electrical Equipment Spaces: Route ductwork to avoid passing through transformer vaults and electrical equipment spaces and enclosures.
- Q. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same metal thickness as duct. Overlap opening on four sides by at least 1-1/2 inches.
- R. 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."
- S. 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.
- T. Coordinate routing with all other trades to establish space requirements for each.
- U. 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.
- V. 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.
- W. 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.
- X. 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.
- Y. 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.
- Z. Install automatic control dampers as recommended by the manufacturer.

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- AA. Prevent passage of unfiltered air around filters with felt, rubber, neoprene gaskets, or other approved safin material.
- BB. 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.
- CC. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- DD. 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.
- EE. Paint ductwork visible behind wall-mounted air outlets and inlets matte black.
- FF. Change duct sizes gradually, not exceeding 30 degrees (15 degrees ideally) divergence and 45 degrees (30 degrees ideally) convergence.
- GG. 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.
- HH. Provide closure flanges around exposed ductwork at wall and ceiling penetrations, 1-1/4 inches wide minimum.
- II. Provide return air grilles open to ceiling plenum with duct boot with minimum longitudinal dimension 2' X 2'.
- JJ. Provide flexible connect between ductwork and all moving equipment.
 - 1. Provide 1-inch slack for free movement.
- KK. 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.
- LL. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction".
- MM. 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.
- NN. Exterior Ductwork:

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1. Slope top of rectangular ductwork to allow proper drainage.
2. Utilize PHP systems or equivalent roof supports with galvanized channels for exterior ductwork. For support loading and spacing, use manufacturer recommendations.

3.2 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. Provide openings in ductwork where required to accommodate thermometers and controllers.
- E. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- F. Cover all exposed fiberglass insulation with duct tape.
- G. During construction provide temporary closures of metal or tape polyethylene on open ductwork to prevent construction dust from entering ductwork system.
- H. Connect flexible ducts to metal ducts with stainless steel bands with worm gear tightener, nylon bands are unacceptable.
- I. Duct transition from round to rectangular and vice versa shall be made with rectangular to round duct transition fitting.
- J. Provide flange-type joint at transverse joints or seal as specified. All transverse joints shall be inspected by the Owner prior to insulating ductwork.
- K. Duct work upstream of air terminal units shall be rigid duct with minimum three diameters of straight ductwork upstream of air terminal units.
- L. Air terminal take-offs from rectangular main ducts shall be lo-loss 45°F take-offs, extractors are not allowed.
- M. 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. Extractors are not allowed.
- N. Do not exceed 6' of flexible duct upstream of each diffuser or grille. See details on Drawings.

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- O. Exhaust grille/register branch duct connections to rectangular mains shall be lo-loss 45° entry fittings with integral balancing damper.
- P. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.
- Q. Plenum construction shall be fully coordinated with other trades to accommodate walls, floor, structure, piping, and other components in the vicinity. All penetrations and joints shall be sealed airtight.

3.3 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).

3.4 INSTALLATION OF 1" AND LESS PRESSURE CLASS DUCTWORK (POSITIVE OR NEGATIVE PRESSURE)

- A. All round duct elbows installed shall be of the adjustable, die-formed, gored, pleated or mitered type. All adjustable elbows shall be sealed after installation.
- B. All mitered elbows shall be equipped with turning vanes.
- C. Connect ceiling diffusers to low pressure ducts with adjustable elbow at duct and short length of flexible duct held in place with strap or clamp. Do not use flexible duct to change direction. Connection detail as well as maximum length of flex duct allowed to diffusers is indicated on the plans.

3.5 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.

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- 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.

3.6 INSTALLATION OF PRE-INSULATED DUCTWORK SYSTEM

- A. Install in accordance with manufacturer's instructions using the fewest joints practical. Unless otherwise indicated, install tight to the building structure, parallel or perpendicular to building lines.
- B. Support: Installer is responsible to ensure duct system is properly and adequately supported using materials that are compatible with the duct system, with supports typically located in straight runs, changes in direction, at branch connections, tee fittings, and in accordance with industry best practices.
 - 1. Dampers and accessories shall be independently supported.
 - 2. Provide flexible connections between ductwork and adjacent materials subject to vibration or movement.
 - 3. If noise and vibration generated by the fan is likely to cause an issue, metal support members shall be separated from ductwork with soft gasket material.
- C. Join sections in accordance with SMACNA Phenolic Duct Construction Standards or using manufacturers system.
- D. Reinforce sections in accordance with SMACNA Phenolic Duct Construction Standards or as recommended by the manufacturer to prevent side deformation from positive or negative pressure.
- E. Apply Kingspan KoolDuct silicone sealant at each internal seam to ensure minimum air leakage.
- F. Tape external seams to ensure a permanent, smooth, wrinkle-free bond.
- G. Install control devices and equipment to allow access for operation, repair, and maintenance.
- H. Install access doors where indicated and where required for concealed equipment, seal air tight.

3.7 CLEANING

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- 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 is 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. Call for inspection by Owner's representative.
- E. Install a fresh set of filters in all equipment immediately prior to project turnover.

3.8 DUCTWORK SCHEDULE

Duct System:	Material:	Longitudinal Joints:	Transverse Joints:	Pressure Class:	Sealant Class:	Leakage Class:	Additional Notes:
Rectangular SA system	Galv. Steel	3A, 3B, 3E	4A, 4C, 4D	+2"	A	24	8B
Round SA system	Galv. Steel	3C, 3E	4B, 4D	+2"	A	12	8B
Rectangular general EA or RA system	Galv. Steel	3A, 3B, 3E	4A, 4C, 4D	-2"	A	24	8B
Round general EA or RA system	Galv. Steel	3C, 3E	4B, 4D	-2"	A	12	8B
Pre-insulated ductwork	Refer to Paragraph 2.6						

DUCTWORK SCHEDULE NOTES:

As an alternate to metal ductwork, contractor can provide pre-insulated ductwork for supply and exhaust air duct located within the attic.

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.
 3D: Snaplock.
 3E: Welded.

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3F: Double-wall, pre-manufactured sheet metal plenum.

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

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.

3.9 PRESSURE TESTING

- A. Perform the following field tests and inspections according to SMACNA’s “HVAC Air Duct Leakage Test Manual” and prepare test reports:
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 3.8.
 4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.
 5. Test 100% of the supply air ductwork, 100% of the return air ductwork, 100% of the exhaust air ductwork,

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- a. Sections to be tested shall be chosen at random by the Owner, Engineer, or Commissioning Agent.
- 6. The complete underground duct system shall be tested for leakage after final assembly.
- 7. Follow SMACNA air duct leakage test standard.
- 8. Allow 24 hours for The BlueDuct sealant to cure after final assembly before testing the duct system. Additional curing time may be required in high ambient conditions.

3.10 CLEANING NEW SYSTEMS

- A. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.
- B. Use service openings, as required, for physical and mechanical entry and for inspection.

END OF SECTION 23 31 13

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SECTION 23 33 00 - DUCTWORK ACCESSORIES

1. GENERAL

1.1 SECTION INCLUDES

- A. Air turning devices.
- B. Duct test holes.
- C. Flexible duct connections.
- D. Volume control dampers.
- E. Gravity Dampers.

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.
 - 1. See Section 23 05 00.
- G. Extra materials.

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1. Provide two of each size and type of fusible link for fire and combination fire/smoke dampers.

2. PRODUCTS

2.1 AIR TURNING DEVICES

- A. Note that air extractors or "scoops" shall not be used under any circumstances.
- B. General:
 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vaness and Vane Runners," and 4-4, "Vane Support in Elbows."
 2. Note that air extractors or "scoops" shall not be used under any circumstances.
- C. 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 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.

2.3 FLEXIBLE DUCT CONNECTIONS

- A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- B. Construct flexible connector of neoprene coated flameproof fabric crimped into duct flanges for attachment to duct and equipment.

2.4 VOLUME CONTROL DAMPERS

- A. Fabricated in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.

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1. Blade: Fabricate of double thickness sheet metal to streamline shape, secured with continuous hinge or rod.
2. Operator: Minimum 3/8 inch square shaft with nylon end bearings at each end to reduce air leakage.

B. Single Blade Dampers: Fabricate for duct sizes up to 6 x 30 inch.

C. Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 8 x 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.

D. End Bearings: Except in round ductwork 6 inches and smaller, provide nylon end bearings on each end. On multiple blade dampers, provide oil-impregnated nylon or sintered bronze bearings.

E. Quadrants:

1. 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.
2. On externally insulated ducts, mount quadrant regulators on stand-off mounting brackets, bases, or adapters to avoid damaging or compression of insulation.
3. Where rod lengths exceed 30 inches, provide regulator at both ends.

F. Remote damper actuators:

1. Provide Young Regulator model 270-896C or equivalent remote volume damper actuator when volume control damper is located above non accessible ceilings. Provide necessary Bowden cable and match manual volume control damper to make for a complete and operable system.

2.5 TAKEOFFS

A. Manufactured high-efficiency takeoff with 45-degree slope on the body, with gauge thickness equal to adjacent ductwork.

2.6 GRAVITY BACKDRAFT DAMPERS

A. Gravity Backdraft Dampers, Size 18 x 18 inches or Smaller, Furnished with Air Moving Equipment: Air moving equipment manufacturers standard construction.

B. 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.

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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. Provide duct access doors:
 - 1. For inspection and cleaning before and after filters, coils, fans, automatic dampers.
 - 2. Elsewhere as indicated on plans.
- C. 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.
- D. 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.
- E. 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. For fans developing static pressures of 5.0 inches and over, cover connections with leaded vinyl sheet, held in place with metal straps.
- F. Provide balancing dampers at points on supply, return, and exhaust systems where indicated on plans.
- G. Provide a high-efficiency takeoff with 45-degree entry for each branch connection.
- H. Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.
- I. The use of splitter dampers is not acceptable.
- J. Install remote manual volume control damper actuators where the volume damper is not accessible. Install all actuator assemblies serving the same room in the same location above the ceiling and near a return air grille or access panel. Label each actuator with the location of the diffuser or grille that it serves.

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1. If an actuator is required to be installed in a ceiling, its location shall be coordinate with the Architect prior to installation and the smallest possible ceiling open and cover shall be provided. Covers should be painted as necessary to match adjacent surfaces.

END OF SECTION 23 33 00

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SECTION 23 34 23 - POWER VENTILATORS

1. GENERAL

1.1 SECTION INCLUDES

- A. Swine wall fans

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

- A. References.

- B. Submittals.

1. General: Submit in accordance with Section 01 33 00 Submittal Procedures
2. Provide dimensional drawings and product data on each fan.
3. Provide fan curves for each fan at the specified operation point, with the flow, static pressure and horsepower clearly plotted.
4. Provide outlet velocity and fan's inlet sound power readings for the eight octave bands, decibels, and sones.
5. Strictly adhere to QUALITY ASSURANCE requirements as stated in section 1.4 of this specification.
6. Provide manufacturer's certification that exhaust fans are licensed to bear Air Movement and Control Association (AMCA), Certified Rating Seal for sound and air performance.
7. Installation, Operation, and Maintenance Manual (IOM): Provide manufacturer's installation, operations, and maintenance manual, including instructions on installation, operations, maintenance, pulley adjustment, receiving, handling, storage, safety information and cleaning. A troubleshooting guide, parts list, warranty and electrical wiring diagrams.

- C. Operation and maintenance data.

1.3 EXTRA MATERIALS

1.4 QUALITY ASSURANCE

- A. Performance ratings: Conform to AMCA standard 211 and 311. Fans must be tested in accordance with ANSI/AMCA Standard 210-99 and AMCA Standard 300-96 in an AMCA accredited laboratory. Fans shall be certified to bear the AMCA label for air and sound performance seal.
- B. Classification for Spark Resistant Construction, levels A, B, and C conform to AMCA 99
- C. 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).

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- D. Comply with the National Electrical Manufacturers Association (NEMA), standards for motors and electrical accessories.
- E. The High Wind models have been analyzed and stamped by a state license P.E. to the ASCE 7-02 Standard which meets the IBC, Florida and Miami-Dade codes.
- F. Each High Wind model is subject to be certified by a third party to the ASTM E330 Static Pressure Difference Standard.
- G. All High Wind models have been analyzed using Computational Fluid Dynamics (CFD). The CFD simulates the flow of high speed (150MPH) winds over the surface of objects.
- H. The Finite Element Analysis (FEA) is the results from the CFD and it can accurately predict the stress, strain, and deflection resulting from high wind loads.

1.5 COORDINATION

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided.
- C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

2. PRODUCTS

2.1 SWINE WALL EXHAUST FANS

- A. Fans to be AP Performer Series or approved equivalent
- B. See schedule for additional requirements.
 - 1. Performer series fans include direct drive, variable speed motors for efficient operation and minimal maintenance. A lifetime warranted composite fiberglass-blend blade won't corrode and is carefully balanced for maximum performance.
 - 2. Performer direct drive fans include the larger 56-frame motor providing higher performance while allowing for much cooler motor temperatures on variable speed applications. Performer direct drive fan motors include a full 3 year warranty
 - 3. Performer fans feature durable and aerodynamic fiberglass housings with stainless steel mounting hardware for corrosion resistance.
 - 4. Heavy duty fan guards with baked-on finish provide additional protection from inclement weather.
 - 5. AP utilizes all aluminum motor mounts constructed of heavy gauge materials
 - 6. Provide with pit transition and custom 2" high density polyethene pit cover

POWER VENTILATORS

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3. EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install power ventilators level and plumb.
- C. Secure roof-mounted fans to roof curbs with cadmium-plated hardware.
- D. Install units with clearances for service and maintenance.
- E. **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.**
 - 1. If unit is approved for operation prior to substantial completion, contractor is fully responsible for all preventative maintenance. Preventative maintenance to be completed per all manufacturer recommendations. In addition, contractor is fully responsible for all cleaning of the systems to the satisfaction of the Owner and Architect/Engineer.

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment according to Division 26 sections.

3.3 FIELD QUALITY CONTROL

- A. 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 stall belt guards.
 - 5. Adjust belt tension.

POWER VENTILATORS

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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.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Replace fan and motor pulleys as required to achieve design airflow.

D. Lubricate bearings.

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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 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

- A. Quality assurance.
 - 1. Test and rate air outlet and inlet performance in accordance with ADC Equipment Test Code 1062 and ASHRAE 70.
 - 2. Test and rate louver performance in accordance with AMCA 500. Submit AMCA certification with submittal.
- B. References.
- C. Submittals.
- D. Operation and maintenance manuals.
- E. Project record documents.
 - 1. Record actual locations of valves.
- F. Delivery, storage, and handling.

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.

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- 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.

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- 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 23 37 00

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SECTION 23 51 00 - BREECHINGS, CHIMNEYS, AND STACKS

1. GENERAL

1.1 SECTION INCLUDES

- A. Listed Type B Vents
- B. Non-foam core CPVC pressure pipe.

1.2 REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

- A. References.
- B. Submittals.
 - 1. Product Data: For the following:
 - a. Special gas vents
 - b. Building-heating-appliance chimneys
 - c. Non-foam core CPVC pressure pipe
 - 2. Shop Drawings: For vents, breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, hangers and seismic restraints, and location and size of each field connection.
 - 3. Welding certificates.
 - 4. Warranty: Special warranty specified in this Section.
- C. Quality Assurance.
 - 1. Source Limitations: Obtain listed system components through one source from a single manufacturer.
 - 2. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code-Steel," for hangers and supports and AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents, breechings, and stacks.
 - 3. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.
- D. Coordination.
 - 1. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.3 REGULATORY REQUIREMENTS

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- A. Conform to applicable code, NFPA 54 (ANSI Z223.1) code for installation of natural gas burning appliances and equipment.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories, Inc., or testing firm acceptable to the authority having jurisdiction] as suitable for the purpose specified and indicated.

2. PRODUCTS

2.1 LISTED TYPE B VENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Schebler
 - 2. Selkirk Inc.
 - 3. Metal-Fab Inc.
 - 4. Or equivalent.
- B. Description: Double-wall metal vents tested according to UL 441 and rated for 480 Deg F continuously for Type B with neutral or negative flue pressure complying with NFPA 211.
- C. Construction: Inner shell and outer jacket separated by at least a 1/4-inch (6-mm) airspace.
- D. Inner Shell: ASTM B 209 (ASTM B 209M), Type 1100 aluminum.
- E. Outer Jacket: Galvanized steel.
- F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
- G. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.

2.2 NON-FOAM CORE CPVC PRESSURE PIPE

- A. Manufacturers: Subject to compliance with requirements, provide product by one of the following:
 - 1. Charlotte Pipe
 - 2. Spears Manufacturing
 - 3. Or equivalent.
- B. Pipe and fittings shall be manufactured from virgin rigid CPVC (chlorinated polyvinyl chloride) vinyl compounds with a Cell Class of 24448 as identified in ASTM D 1784.

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- C. CPVC pipe and fittings shall conform to ASTM D 2846. Pipe and fittings shall be manufactured as a system and be the product of one manufacturer. All pipe and fittings shall be manufactured in the United States. Pipe and fittings shall conform to National Sanitation Foundation (NSF) Standards 14 and 61.

3. EXECUTION

3.1 EXAMINATION AND STORAGE

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.

- 1. Proceed with installation only after unsatisfactory conditions have been corrected.

- B. Store delivered materials inside, out of the weather. Protect materials from accidental damage or vandalism.

3.2 INSTALLATION - GENERAL

- A. Installation shall comply with latest installation instructions published by the manufacturer and shall conform to all local plumbing, building and fire code requirements. Solvent weld joints shall be made using CPVC cement conforming to ASTM F 493. Yellow one-step cement may be used without primer. If a primer is required by local plumbing or building codes, then a primer conforming to ASTM F 656 should be used. The system shall be protected from chemical agents, fire stopping materials, thread sealant, plasticized vinyl products or other aggressive chemical agents not compatible with CPVC compounds.

- B. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

- C. Support at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

- D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

- E. Lap joints in direction of flow.

- F. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

- G. Maintain minimum clearances from combustibles specified in UL listing.

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- H. Level and plumb chimney and stacks.
- I. At appliances, provide slip joints permitting removal of appliances without removal or dismantling of breechings, breeching insulation, chimneys, or stacks.
- J. Finish: All aluminized surfaces exposed to the atmosphere shall be protected by a minimum of one base coat and one finish coat of paint.

3.3 SCHEDULES

A. <u>EQUIPMENT</u>	<u>System</u>
Water Heater	CPVC
Unit Heater	Listed B VENT

3.4 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.
- B. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.
- C. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

END OF SECTION 23 51 00

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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.

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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

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- 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. Aeon, 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.

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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

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- 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 through 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°C to +20°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

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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

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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 additional 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

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- 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 25° 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

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- 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.

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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

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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

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- 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.

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- 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

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SECTION 23 74 33 – PACKAGED ROOFTOP VENTILATORS

1. GENERAL

1.1 SECTION INCLUDES

- A. Packaged rooftop ventilators
- B. Section 23 07 13- Ductwork Insulation.
- C. Section 22 10 00 - Plumbing Piping: Equipment drains.
- D. Section 23 31 13 - Ductwork.
- E. Section 23 33 00 - Ductwork Accessories: Flexible duct connections.

1.2 REFERENCES

- A. See Section 23 05 00.

1.3 SUBMITTALS

- A. See Section 23 05 00.
 - 1. Provide literature which indicates dimensions, weights, capacities, ratings, fan performance, gages and finishes of materials, and electrical characteristics and connection requirements.
 - 2. Certified coil performance data. All coil performance data shall be computer generated.
 - 3. Provide data of filter media, filter performance data, filter assembly, and filter frames.
 - 4. Provide fan curves with specified operating point clearly plotted.
 - 5. Submit sound power level data for both fan outlet and casing radiation at rated capacity.
 - 6. Submit computer-generated selection for drive belts and pulleys. Provide documentation that the drive system has been evaluated over the full operating speed range of the fan.

1.4 OPERATION AND MAINTENANCE DATA

- A. See Section 23 05 00.

1.5 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five (5) years documented experience, who issues complete catalog data on total product.

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1.6 DELIVERY, STORAGE, AND HANDLING

- A. See Section 23 05 00.
- B. Unit shall ship with all openings securely covered with wood and / or nylon reinforced plastic wrap and to be watertight. Each unit (will be covered by a tarp) and securely strapped down on an open flatbed truck.
- C. Units must be stored in a clean dry area and protected from the weather and construction traffic. Carefully follow manufacturers' storage instructions if installation does not immediately follow arrival at the job site.
- D. Follow manufacturers rigging guidelines for movement and installation of equipment.

1.7 ENVIRONMENTAL REQUIREMENTS

- A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fans have been test run under observation.

1.8 EXTRA MATERIALS

- A. Provide one extra full replacement set of each type of filters for each unit scheduled.

1.9 WARRANTY

- A. Unit manufacturer to warrant its product to be free of defects in materials and workmanship under normal use when installed and operated in accordance with factory recommendations for a period of 18 months from date of shipment or 12 months after initial equipment start-up, whichever ever occurs first. Equipment found to be defective should be replaced or repaired to include all parts and labor. Component parts that require periodic replacement due to normal wear such as filters, fan belts, etc. are not covered by the warranty.

2. PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with specifications contained within this document, manufacturers offering products that may be incorporated into the work include but are not limited to:
 - 1. Aeon
 - 2. Diakin

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3. Trane

2.2 MANUFACTURED UNITS

2.3 Rooftop Units

2.4 General Description

- A. Packaged rooftop unit shall include compressors, evaporator coils, filters, supply fans, dampers, air-cooled condenser coils, condenser fans, reheat coil, gas heaters, VFDs and unit controls.
- B. Unit shall be factory assembled and tested including leak testing of the DX coils, pressure testing of the refrigeration circuit, and run testing of the completed unit. Run test report shall be supplied with the unit in the service compartment's literature pocket.
- C. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
- D. Unit components shall be labeled, including refrigeration system components and electrical and controls components.
- E. Estimated sound power levels (dB) shall be shown on the unit ratings sheet.
- F. Installation, Operation, and Maintenance manual shall be supplied within the unit.
- G. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's hinged access door.
- H. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's hinged access door.

2.5 Construction

- A. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.
- B. Unit insulation shall have a minimum thermal resistance R-value of 13. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D1929-11 for a minimum flash ignition temperature of 610°F.
- C. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents moisture accumulation on the insulation,

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provides a cleanable interior, reduces heat transfer through the panel, and prevents exterior condensation on the panel.

- D. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 340/360. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, at a maximum 8 inches of positive or negative static pressure, to reduce air leakage. Deflection shall be measured at the midpoint of the panel height and width. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.
 - E. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors.
 - F. Access to filters, dampers, cooling coils, reheat coil, heaters, compressors, and electrical and controls components shall be through hinged access doors with quarter turn, zinc cast, lockable handles. Full-length stainless-steel piano hinges shall be included on the doors.
 - G. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.
 - H. Units with cooling coils shall include double sloped 304 stainless steel drain pans.
- 2.6 Unit shall be provided with horizontal discharge and horizontal return air openings. All openings through the base pan of the unit shall have upturned flanges of at least 1/2 inch in height around the opening.
- A. Unit shall include lifting lugs on the top of the unit.
 - B. Unit shall include factory installed, painted galvanized steel condenser coil guards on the face of the condenser coil.
- 2.7 Electrical
- A. Unit shall have a 5kAIC SCCR.
 - B. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.
 - C. Unit shall be provided with a factory installed and factory wired 115V, 12-amp GFI outlet disconnect switch in the unit control panel.

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- D. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more than 10% out of balance on voltage, the voltage is more than 10% under design voltage or on phase reversal.

2.8 Supply Fans

- A. Unit shall include direct drive, unhooded, backward curved, plenum supply fans.
- B. Blowers and motors shall be dynamically balance and mounted on rubber isolators.
- C. Motors shall be premium efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.
- D. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be premium efficiency.

2.9 Cooling Coils

- A. Evaporator Coils
 - 1. Coils shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and galvanized steel end casings. Fin design shall be sine wave rippled.
 - 2. Coils shall have interlaced circuitry and shall be standard capacity.
 - 3. Coils shall be hydrogen or helium leak tested.
 - 4. Coils shall be furnished with factory installed expansion valves.

2.10 Refrigeration System

- A. Unit shall be factory charged with R-410A refrigerant.
- B. Compressors shall be scroll type with thermal overload protection and carry a 5-year non-prorated warranty, from the date of original equipment shipment from the factory.
- C. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged compressor access doors shall be fabricated of double wall, rigid polyurethane foam injected panels to prevent the transmission of noise outside the cabinet.
- D. Compressors shall be isolated from the base pan with the compressor manufacturer's recommended rubber vibration isolators, to reduce any transmission of noise from the compressors into the building area.

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- E. Each refrigeration circuit shall be equipped with expansion valve type refrigerant flow control.
- F. Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low pressure sides and a factory installed liquid line filter driers.
- G. Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low pressure sides and a factory installed replaceable core liquid line filter driers.
- H. Unit shall include a variable capacity scroll compressor on the lead refrigeration circuit which shall be capable of modulation from 10-100% of its capacity.
- I. Lead refrigeration circuit shall be provided with hot gas reheat coil, modulating valves, electronic controller, supply air temperature sensor and a control signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.
- J. Each refrigeration circuit shall be equipped with a liquid line sight glass.
- K. Each refrigeration circuit shall be equipped with suction and discharge compressor isolation valves.

2.11 Condensers

A. Air-Cooled Condenser

- 1. Condenser fans shall be a vertical discharge, axial flow, direct drive fans.
- 2. Coils shall be designed for use with R-410A refrigerant. Coils shall be multi-pass and fabricated from aluminum microchannel tubes.
- 3. Coils shall be designed for a minimum of 10°F of refrigerant sub-cooling.
- 4. Coils shall be hydrogen or helium leak tested.
- 5. Condenser fans shall be high efficiency electrically commutated motor driven with factory installed head pressure control module. Condenser airflow shall continuously modulate based on head pressure and cooling operation shall be allowed down to 35°F with adjustable compressor lockout.
- 6. Condenser fans shall be VFD driven variable speed for condenser head pressure control. Factory provided and factory programmed VFDs shall continuously modulate the fan air flow to maintain head pressure at acceptable levels. Cooling operation shall be allowed down to 35°F with adjustable compressor lockout.

2.12 Gas Heating

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- A. Stainless steel heat exchanger furnace shall carry a 25-year non-prorated warranty, from the date of original equipment shipment from the factory.
- B. Gas furnace shall consist of stainless steel heat exchangers with multiple concavities, an induced draft blower and an electronic pressure switch to lockout the gas valve until the combustion chamber is purged and combustion airflow is established.
- C. Furnace shall include a gas ignition system consisting of an electronic igniter to a pilot system, which will be continuous when the heater is operating, but will shut off the pilot when heating is not required.
- D. Unit shall include a single gas connection and have gas supply piping entrances in the unit base for through-the-curb gas piping and in the outside cabinet wall for across the roof gas piping.
- E. High Turndown Modulating Natural Gas Furnace shall be equipped with modulating gas valves, adjustable speed combustion blowers, stainless steel tubular heat exchangers, and electronic controller. Combustion blowers and gas valves shall be capable of modulation. Electronic controller includes a factory wired, field installed supply air temperature sensor. Sensor shall be field installed in the supply air ductwork. Supply air temperature setpoint shall be adjustable on the electronic controller within the controls compartment. Gas heater shall be capable of capacity turndown ratio as shown on the unit rating sheet. Heat trace shall be including on the condensate drain
- F. Auxiliary gas heating capacity shall be sized to meet heating leaving air temperature setpoint when heat pump heating is in operation. Auxiliary heating capacity shall be available for operation when heat pump heating is in operation.

2.13 Filters

- A. Unit shall include 1-inch aluminum mesh pre filters upstream of the outside air opening.
- B. Unit shall include a clogged filter switch.
- C. Unit shall include a Magnehelic gauge mounted in the controls compartment.
- D. Outside Air/Economizer
- E. Unit shall include 100% motor operated outside air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge and end seals. Damper blades shall be gear driven and designed to have no more than 20 cfm of leakage per sq. ft. at 4 in. w.g. air pressure differential across the damper. Low leakage dampers shall be Class 2 AMCA certified, in accordance with AMCA Standard 511. Damper assembly shall be controlled by spring return, 2 position actuator. Unit shall include outside air opening bird screen and outside air hood.

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2.14 Controls

- A. Installed and Factory Provided Controller
- B. Unit controller shall be capable of controlling all features and options of the unit. Controller shall be factory installed in the unit controls compartment and factory tested. Controller shall be capable of standalone operation with unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling available without dependence on a building management system.
- C. Controller shall have an onboard clock and calendar functions that allow for occupancy scheduling.
- D. Controller shall include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.
- E. Makeup Air Controller
 - 1. Unit shall modulate cooling with constant airflow to meet ventilation outside air loads. Cooling capacity shall modulate based on supply air temperature.
 - 2. With modulating hot gas reheat, unit shall modulate cooling and hot gas reheat as efficiently as possible, to meet outside air humidity loads and prevent supply air temperature swings and overcooling of the space.
 - 3. Unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling shall be accomplished with connection to interface module with LCD screen and input keypad, interface module with touch screen, or with connection to PC with free configuration software. Controller shall be capable of connection with other factory installed and factory provided unit controllers with individual unit configuration, setpoint adjustment, sensor status viewing, and occupancy scheduling available from a single unit. Connection between unit controllers shall be with a modular cable. Controller shall be capable of communicating and integrating with BACnet network.
- F. RTU provider shall provide web-based interface service for user to view unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling for 12 months after the substantial completion date.
- G. Variable Air Volume controls with Variable Frequency Drive: Provide variable air volume supply air temperature control with variable frequency drive. Provide all necessary controls to operate a VAV rooftop from supply air temperature including microprocessor controller and supply air sensor. The microprocessor shall coordinate the of cooling with supply air temperature reset capability. Variable frequency drive shall be factory installed and tested to provide supply fan motor speed modulation based upon the supply air static pressure setpoint.

3. EXECUTION

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3.1 INSTALLATION

- A. Examine rough-in for hydronic, condensate drainage piping and electrical to verify actual locations of connections prior to installation.
- B. Do not proceed until all unsatisfactory conditions have been corrected.
- C. Install central-station air-handling units level and plumb, in accordance with manufacturer's written instructions, on minimum 6" high base rail.
 - 1. Base rail height shall be coordinated with required height for drain pan condensate traps. If additional height is required, supplier shall notify Engineer in submittal data.
- D. Support floor-mounted units on concrete equipment bases. Secure units to anchor bolts installed in concrete equipment base.
- E. Arrange installation of units to provide maximum access space around air-handling units for service and maintenance.
- F. If unit is operated prior to substantial completion, contractor is fully responsible for all preventative maintenance. Preventative maintenance to be completed per all manufacturer recommendations.

3.2 EQUIPMENT BASES

- A. See Section 23 05 00.

3.3 COMMISSIONING

- A. Perform the following operations and checks before start-up:
 - 1. Adjust damper linkages for proper damper operation.
 - 2. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, and coils entering air face.
 - 3. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
 - 4. Comb coil fins for parallel orientation.
 - 5. Install clean filters. Install clean filters again at time of substantial completion.
 - 6. Measure and record motor electrical values for voltage and amperage.
- B. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for procedures for air-handling-system testing, adjusting, and balancing.

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- C. Engage a factory authorized service representative to train owner's maintenance personnel to adjust, operate and maintain the entire unit. Refer to Division 01 Section Closeout Procedures and Demonstration and Training.

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SECTION 23 81 27 –VARIABLE REFRIGERANT FLOW SYSTEM

1. GENERAL

1.1 SECTION INCLUDES:

- A. VRV Outdoor Units
- B. Outdoor Heat Recovery Unit Rack Systems
- C. Branch Selector Boxes
- D. VRV Indoor Fan Coil Units
- E. VRV System Controls

1.2 QUALITY ASSURANCE

- A. The units shall be listed by Electrical Laboratories (ETL) and bear the ETL label.
- B. All wiring shall be in accordance with the National Electrical Code (N.E.C.).
- C. The units shall be manufactured in a facility registered to ISO 9001 and ISO14001 which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).
- D. All units must meet or exceed the 2010 Federal minimum efficiency requirements and the proposed ASHRAE 90.1 efficiency requirements for VRF systems. Efficiency shall be published in accordance with the DOE alternative test procedure, which is based on the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standards 340/360, 1230 and ISO Standard 13256-1.
- E. A full charge of R-410A for the condensing unit only shall be provided in the condensing unit.

1.3 DELIVERY, STORAGE AND HANDLING

- A. Unit shall be stored and handled according to the manufacturer's recommendation.

1.4 CONTROLS

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- A. The VRF product manufacturer shall provide a control system that consists of a low voltage communication network of unitary built-in controllers with on-board communications and a web-based operator interface. A web controller with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface.
- B. System controls and control components shall be installed in accordance with the manufacturer's written installation instructions.
- C. Furnish energy conservation features such as optimal start, night setback, request-based logic, and demand level adjustment of overall system capacity as specified in the sequence.
- D. Provide capability for future system expansion to include monitoring and use of occupant card access, lighting control and general equipment control.
- E. Control system start-up shall be a required service to be completed by the manufacturer or a duly authorized, competent representative that has been factory trained in controls system configuration and operation. This service shall be equipment and system count dependent and shall be a minimum of one (1) eight (8) hour period to be completed during normal working hours.

2. WARRANTY

- 2.1 The units shall be covered by the manufacturer's limited warranty for a period of one (1) year from date of installation. Mechanical contractor to coordinate with supplying contractor requirements to meet warranty, typ.
- 2.2 10 YEAR PARTS AND COMPRESSOR WARRANTY:
 - A. The units shall have a manufacturer's all-parts warranty for a period of ten (10) years from date of factory certified start-up.
 - B. The compressors shall also have a manufacturer's warranty of ten (10) years from date of factory certified start up.

3. PRODUCTS

- 3.1 APPROVED MANUFACTURERS
 - A. Daikin Company
 - B. Mitsubishi Electric Company

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C. LG

D. Other manufacturers not listed above shall submit for prior approval.

E. General:

1. The variable capacity heat recovery air conditioning system shall be a Daikin Variable Refrigerant Volume Series (heat or cool model) system as specified.
2. The system shall consist of multiple evaporators, branch selector boxes, REFNET™ joints and headers, a three-pipe refrigeration distribution system using PID control and Daikin VRV® condenser unit.
3. The condenser shall be a direct expansion (DX), air-cooled heat recovery, multi-zone air-conditioning system with variable speed inverter driven compressors using R-410A refrigerant.
4. The condensing unit may connect an indoor evaporator nominal capacity up to 200% of the condensing unit nominal capacity. All zones are each capable of operating separately with individual temperature control.
5. A dedicated hot gas pipe shall be required to ensure optimum heating operation performance.
 - a. Two-pipe, heat recovery systems utilizing a lower temperature mixed liquid/gas refrigerant to perform heat recovery are not acceptable due to reduced heating capabilities.
6. The Daikin condensing unit shall be able to connect to indoor unit models CXTQ, FXFQ, FXHQ, FXMQ, FXLQ, FXNQ, FXSQ, FXTQ, FXDQ, FXZQ, FXUQ, FXEQ, FXAQ and FXMQ_MF, and shall range in capacity from 5,800 Btu/h to 96,000 Btu/h in accordance with Daikin's engineering data book detailing each available indoor unit.
 - a. The indoor units shall be connected to the condensing unit utilizing Daikin's REFNET™ specified piping joints and headers to ensure correct refrigerant flow and balancing. T style joints are not acceptable for a variable refrigerant system.
7. Operation of the system shall permit either individual cooling or heating of each indoor unit simultaneously or all of the indoor units associated with each branch of the cool/heat selector box (BSQ_T / BS_Q54T / BSF_Q54T). Each indoor unit or group of indoor units shall be able to provide set temperature independently via a local remote controller, an Intelligent Controller, an Intelligent Manager or a BMS interface.
8. Branch selector boxes:
 - a. The branch selector boxes shall have the capacity to control up to 290 MBH (cooling) downstream of the branch selector box.
 - b. Each branch of the branch selector box shall consist of three electronic expansion valves, refrigerant control piping and electronics to facilitate communications between the box and main processor and between the box and indoor units.

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- c. The branch selector box shall control the operational mode of the subordinate indoor units. The use of three EEV's ensures continuous heating during defrost (multiple condenser systems), no heating impact during changeover and reduced sound levels.
 - d. The use of solenoid valves for changeover and pressure equalization shall not be acceptable due to refrigerant noise.
 9. The REYQ_XA condensing unit model numbers and the associated number of connectable indoor units per REYQ_XA condensing unit is indicated in the following table. Each indoor unit or group of indoor units shall be independently controlled.
- B. Installation Requirements
 1. The system must be installed by Daikin factory trained contractor. The bidders shall be required to submit training certification proof with bid documents. The mechanical contractor's installation price shall be based on systems installation requirements. The mechanical contractor bids with complete knowledge of the HVAC system requirements.
 2. The mechanical contractor shall maintain training certification certificates of all employees working on the project side related to the VRV systems. These certificates will be kept in the construction trailer of the General Contractor or Construction Manager. The General Contractor or Construction Manager may review certified payroll documentation to verify that all the VRV installers have a certificate on file. Violation of the proper certification will cause immediate removal of the employee.

3.2 OUTDOOR/CONDENSING UNIT

A. GENERAL:

1. The condensing unit is designed specifically for use with VRV IV X series components.
2. The condensing unit shall be factory assembled in the USA and pre-wired with all necessary electronic and refrigerant controls.
3. The refrigeration circuit of the condensing unit shall consist of Daikin inverter scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports, liquid receiver and suction accumulator.
4. High/Low pressure gas line, liquid and suction lines must be individually insulated between the condensing and indoor units.
5. The condensing unit can be wired and piped with access from the left, right, rear or bottom.
6. The connection ratio of indoor units to condensing unit shall be permitted up to 200% of nominal capacity.
7. Each condensing system shall be able to support the connection of up to 64 indoor units dependent on the model of the condensing unit.
8. The sound pressure level standard shall be that value as listed in the Daikin engineering manual for the specified models at 3 feet from the front of the unit. The condensing unit shall be capable of operating automatically at further reduced noise during night time or via an external input.

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9. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for reprogramming.
10. The condensing unit shall be modular in design and should allow for side-by-side installation.
11. The following safety devices shall be included on the condensing unit; high pressure sensor and switch, low pressure sensor, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
12. To ensure the liquid refrigerant does not flash when supplying to the various indoor units, the circuit shall be provided with a sub-cooling feature.
13. Oil recovery cycle shall be automatic occurring 2 hours after start of operation and then every 8 hours of operation. Each system shall maintain continuous heating during oil return operation.
14. The condensing unit shall be capable of heating operation at -13°F (-25°C) wet bulb ambient temperature without additional low ambient controls or an auxiliary heat source.
15. The multiple condenser VRV systems shall continue to provide heat to the indoor units in heating operation while in the defrost mode.

B. UNIT CABINET:

1. The condensing unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed galvanized steel panels coated with a baked enamel finish.

C. FAN:

1. The condensing unit shall consist of one or more propeller type, direct-drive 800W fan motors that have multiple speed operation via a DC (digitally commutating) inverter. Reference table below.

MODEL NUMBER	FAN MOTOR OUTPUT (W) & QUANTITY
REYQ72XATJ*	800 x 2

2. The condensing unit fan motor shall have multiple speed operation of the DC (digitally commutating) inverter type, and be of high external static pressure and shall be factory set as standard at 0.12 in. WG. A field setting switch to a maximum 0.32 in. WG pressure is available to accommodate field applied duct for indoor mounting of condensing units.
3. The condensing unit shall have configurable settings for intermittent fan operation to help minimize snow accumulation on fan blades when the system is off.
4. The fan shall be a vertical discharge configuration with a nominal airflow maximum range of 7,283 CFM to 28,440 CFM dependent on model specified.
5. The fan motor shall have inherent protection and permanently lubricated bearings and be mounted.
6. The fan motor shall be provided with a fan guard to prevent contact with moving parts.

D. SOUND:

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1. Nominal sound pressure levels shall be as shown below.

MODEL NUMBER	SOUND PRESSURE LEVEL dB(A)
REYQ72XATJ*	58

2. Night setback control of the fan motor for low noise operation by way of automatically limiting the maximum speed shall be a standard feature. Operation sound level shall be selectable from 3 steps.

OPERATION SOUND dB(A)	NIGHT MODE SOUND PRESSURE LEVEL dB(A) APPROX.
Level 1	55
Level 2	50
Level 3	45

E. CONDENSER COIL:

1. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The heat exchanger coil shall be of a waffle louver fin and rifled bore tube design to ensure high efficiency performance.
3. The heat exchanger on the condensing units shall be manufactured from Hi-X seamless copper tube with N-shape internal grooves mechanically bonded on to aluminum fins to an e-Pass Design.
4. The fins shall be coated with an anti-corrosion hydrophilic blue coating as standard from factory with a salt spray test rating of 1000hr per ASTM B117 test standards.
5. The outdoor coil shall have three-circuit heat exchanger design eliminating the need for a drain pan heater. The lower part of the coil shall be used for inverter cooling and be on or off during operation enhancing the defrost operation.
 - a. An alternate manufacturer must provide a drain pan heater to enable adequate defrosting of the unit in defrost operation.
6. The condensing unit shall be factory equipped with condenser coil guards on all sides.

F. COMPRESSOR:

1. The Daikin inverter Flash Vapor injection scroll compressors shall be variable speed (PVM inverter) controlled which is capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit.

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- a. In addition, samplings of evaporator and condenser temperatures shall be made so that the high/low pressures detected are read every 20 seconds and calculated. With each reading, the compressor capacity (INV frequency) shall be controlled to eliminate deviation from target value.
 - 1) Non –inverter-driven compressors, which may cause starting motor current to exceed the nominal motor current (RLA) and require larger wire sizing, shall not be allowed.
2. The inverter driven compressors in the condensing unit shall be of highly efficient reluctance DC (digitally commutating), hermetically sealed scroll “K-type”.
3. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type.
 - a. At complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.
4. The capacity control range shall be as low as 3% to 100%.
5. The compressor's motor shall have a cooling system using discharge gas, to avoid sudden changes in temperature resulting in significant stresses on winding and bearings.
6. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
7. Oil separators shall be standard with the equipment together with an intelligent oil management system.
8. The compressor shall be mounted on vibration dampening rubber grommets to minimize the transmission of vibration, eliminating the standard need for external spring isolation.
9. In the event of compressor failure, the remaining compressors, if applicable, shall continue to operate and provide heating or cooling as required at a proportionally reduced capacity. The microprocessor and associated controls shall be manually activated to specifically address this condition for single module and manifold systems.
10. In the case of multiple condenser modules, combined operation hours of the compressors shall be balanced by means of the Duty Cycling Function, ensuring sequential starting of each module at each start/stop cycle, completion of oil return, completion of defrost or every 8 hours. When connected to a central control system sequential start is activated for all system on each DIII network.
11. Compressor configurations:

MODEL NUMBER	COMPRESSOR MOTOR OUTPUT (W)	QUANTITY	COMPRESSOR TYPES
REYQ72XATJ*	3,900	1	Inverter controlled

G. PERFORMANCE:

1. The VRV IV REYQ_XA system shall perform as indicated below:

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MODEL NUMBER	SYSTEM IEER (Ducted)	SYSTEM IEER (Non-Ducted)
REYQ72XATJ*	21.30	25.20

MODEL NUMBER	SYSTEM SCHE (Ducted)	SYSTEM SCHE (Non-Ducted)
REYQ72XATJ*	22.00	26.10

MODEL NUMBER	SYSTEM EER (Ducted)	SYSTEM EER (Non-Ducted)
REYQ72XATJ*	13.90	15.80

MODEL NUMBER	SYSTEM COP@47°F (Ducted)	SYSTEM COP@47°F (Non-Ducted)
REYQ72XATJ*	3.68	4.30

MODEL NUMBER	SYSTEM COP@17°F (Ducted)	SYSTEM COP@17°F (Non-Ducted)
REYQ72XATJ*	2.25	2.50

1. Performance Conditions:

- a. Cooling: Indoor temperature of 80°FDB (26.7°CDB), 67°FWB (19.5°CWB) and outdoor temperature of 95°FDB (35°CDB).
- b. Heating: Indoor temperature of 70°FDB (21.1°CDB) and outdoor temperature of 47°FDB (8.3°CDB), 43°FWB (6.1°CDB).
- c. Equivalent piping length: 25ft (7.5m)

2. Cooling or Cooling Dominant Operation:

- a. The standard operating range in cooling or cooling dominant simultaneous cooling/heating will be 23°FDB (-5°CDB) ~ 122°FDB (50°CDB).
- b. Cooling mode indoor room temperature range will be 57-77°FWB (13.8 - 25°CWB).
- c. Each system as standard shall be capable of onsite reprogramming to allow low ambient cooling operation down to -4°FDB (-20°CDB).

3. Heating or Heating Dominant Operation:

- a. The standard operating range in heating or heating dominant simultaneous cooling/heating will be -13° – 61°FWB (-25 – 16°CWB).

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- 1) If an alternate equipment manufacturer is selected, the mechanical contractor shall provide, at their own risk and cost, all additional material and labor to meet low ambient operating condition and performance

b. Heating mode indoor room temperature range will be 59°FDB - 80°F DB (15°CDB – 26.7°CDB).

H. ELECTRICAL:

1. The power supply to the condensing unit shall be:

POWER SUPPLY VOLTAGE		VOLTAGE RANGE	
208-230V / 3ph / 60 Hz		187V – 253V (±10%)	

MODEL	MCA	MOP	COMPRESSOR RLA
REYQ72XATJ*	38.1	45	20.8

I. WIRING:

1. The control voltage between the indoor and condensing unit shall be 16VDC non-shielded, stranded 2 conductor cable.
2. The control wiring shall be a two-wire multiplex transmission system, making it possible to connect multiple indoor units to one condensing unit with one 2-cable wire, thus simplifying the wiring installation.
3. The control wiring maximum lengths shall be as shown below:

	CONDENSER TO INDOOR UNIT	CONDENSER TO CENTRAL CONTROLLER	INDOOR UNIT TO REMOTE CONTROL
CONTROL WIRING LENGTH	6,560ft (2,000m)	3,280ft (1,000m)	1640 ft. (500m)
WIRE TYPE	16/18 AWG, 2 wire, non-polarity, non-shielded, stranded		

J. REFRIGERANT PIPING:

1. The system shall be capable of refrigerant piping up to 540ft (165m) actual or 623ft (190m) equivalent from the condensing unit to the furthest indoor unit, a total combined liquid line length of 3,280ft (1,000m) of piping between the condensing and indoor units with 295 feet maximum vertical difference, without any oil traps or additional components.
2. REFNET™ piping joints and headers shall be used to ensure proper refrigerant balance and flow for optimum system capacity and performance.

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- a. T style joints shall not be acceptable as this will negatively impact proper refrigerant balance and flow for optimum system capacity and performance.

K. PAINT/CORROSION RESISTANCE:

1. Paint and corrosion resistance shall be at a minimum per the table below:

COMPONENT	VRV IV X		
	BASE MATERIAL	SURFACE TREATMENT	COATING THICKNESS
			External & Internal Surface
EXTERNAL PANEL BASE	Galvanized steel	POLYESTER	≥1.5 mils
EXTERNAL FRONT PANEL	Galvanized steel	POLYESTER	≥1.5 mils
PILLAR	Galvanized steel	POLYESTER	≥1.5 mils
COMPRESSOR COVER	ASTM material	Resin Paint	≥0.78 mils
FIN GUARD	Iron wire	Resin Paint	≥0.79 mils
FAN GUARD AND DRUM	Polypropylene	No treatment required	N/A
FAN	Acrylonitrile - glass	No treatment required	N/A
FAN MOTOR FRAME	Resin	No treatment required	N/A
FAN MOTOR SHAFT	Carbon steel	No treatment required	N/A
FAN MOTOR SUPPORT	Galvanized steel	POLYESTER	≥1.5 mils
HEAT EXCHANGERS (FIN ONLY)	Aluminum	Polymer Anti-corrosion surface treatment	Salt Spray 1000 hours, blister rating 10
ELECTRICAL PARTS BOX	Hot-dip zinc-coated steel	No treatment required	N/A
ELECTRICAL PARTS BOARD	Glass cloth / Glass nonwoven cloth material	Insulation Varnish	No specific thickness
SCREWS	Carbon steel wire rods	High corrosion resistance treatment	≥0.28 mils

3.3 OUTDOOR HEAT RECOVERY UNIT RACK SYSTEMS

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A. DESCRIPTION:

1. The following specification details the minimum requirement for equipment and structure for a complete factory assembled condensing unit system.
2. The condensing unit system shall be designed for the heat transfer as designed on the plans. It shall be arranged to fit the space allotted on the plans and allow for equipment service and future removal of condensing units.
3. The condensing unit system shall be factory fabricated, assembled and delivered to site as a complete unit containing all of the items listed under Products. Field fabrication and assembly of the condensing unit system is not acceptable. The condensing unit system shall only require refrigerant piping connections, single point electrical power connection and single point control wire connection.
4. The following products are to be included as part of the condensing unit system:
 - a. VRV Condensing Units
 - b. Control Wire System
 - c. Electrical Wiring System
 - d. Electrical Means of Disconnect and Overcurrent Protection for each unit
 - e. Electrical Support System
 - f. Structural Steel Base

B. PRODUCT:

1. Structural Base Requirements: Steel base shall be designed to accommodate the total weight of the installed condensing units, electrical components and lifting requirements. Base shall be designed to allow field required refrigerant piping and power wiring to be installed under the base/condensing units. Refrigerant piping installed on the walk paths or next to condensing unit access panels are not acceptable. Base shall include lifting lugs designed for single lift. Lifting the condensing unit system by the condensing units is not acceptable. The vendor must provide Professional Engineer documentation, signed and sealed, demonstrating this requirement is met.
2. Walkways: Provide walkways as shown on plans. Walkways shall be open, de-bossed, slip resistant, hot dipped galvanized safety grating. Walkways shall be removable to allow access to condensing units and refrigerant piping.
3. Finish: All steel shall be hot dipped galvanized after fabrication.
4. Control Wiring/System: Condensing unit system shall be factory wired and tested. System shall be equipped with terminal blocks in a NEMA 3R enclosure. Terminal block shall have all condensing unit outputs landed on it and shall have as many inputs as required for single point control wiring connections to the building control system. Wire type shall be 16 AWG, 2 wire, non-polarity, non-shielded, stranded. Control wiring diagram shall be printed on weather resistant material and affixed to the inside of the control panel enclosure door.

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5. **Electrical System:** Condensing unit system shall be factory wired and tested. System shall be equipped with an integral power panel that powers ancillary closely located equipment such as rooftops, exhaust fans, other HVAC systems. Power panel shall be an exterior rated, NEMA 3R enclosure, specification grade with hinged door and lock. Voltage, amperage and short circuit rating shall be project specific as required. Branch circuit breakers shall serve as condensing unit means of disconnect and overcurrent protection per National Electric Code (NEC) requirements and equipment manufacturer recommendations. Raceway shall be routed from the electrical power panel to the equipment concealed and in a neat and workman like manner. Raceway routed under equipment shall be properly supported to minimize raceway sagging and be clear of refrigerant piping opening in the bottom of the condensing units. Raceway routed below equipment shall be liquid tight flexible metal conduit (LFMC) suitable for the application. Raceway routed below the walkway shall be intermediate metal conduit (IMC).
6. **Equipment Identification:** Condensing Unit System name plate, all condensing units and circuit breakers shall be labeled with nameplates. Nameplates shall be 1/16 inch thick white core, black surface, laminated plastic with beveled edges.
7. **Installation:** The condensing unit system shall be installed and braced in accordance with projects plans and specifications. Field erected support system, equipment rails or other supporting devices shall be provided by the Contractor.

3.4 **BRANCH SELECTOR UNITS**

A. **GENERAL:**

1. **SINGLE-PORT BRANCH SELECTOR BOX**

- a. The BSQ36TVJ, BSQ60TVJ, and BSQ96TVJ, are designed specifically for use with VRV IV, VRV IV X, and RWEQ series heat recovery system components.
- b. The single port branch selector boxes BSQ_T shall provide individual control and changeover for one group of indoor units.
- c. These BSQ_T branch controllers shall support low ambient cooling down to -4F° to connected indoor units.
- d. These selector boxes shall be factory assembled, wired, and piped.
- e. These branch selector boxes shall have a heat-by-pass control loop inside the units to prevent overheating of space during heating cycles
- f. These selector boxes must be mounted indoors.
- g. When simultaneously heating and cooling, the units in heating mode shall energize their subcooling electronic expansion valve.

2. **STANDARD MULTI-PORT T-SERIES BRANCH SELECTOR BOX**

- a. The BS4Q54TVJ, BS6Q54TVJ, BS8Q54TVJ, BS10Q54TVJ and BS12Q54TVJ, are designed specifically for use with VRV IV, VRV IV X, and RWEQ series heat recovery system components.

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- b. These branch selector boxes shall provide individual control and changeover for multiple groups of indoor units.
- c. These selector boxes shall be factory assembled, wired, and piped.
- d. These selector boxes must be mounted indoors.
- e. When simultaneously heating and cooling, the units in heating mode shall energize their subcooling electronic expansion valve.

3. MULTI-PORT FLEX BRANCH SELECTOR BOX SERIES

- a. The BSF4Q54TVJ, BSF6Q54TVJ, and BSF8Q54TVJ are designed specifically for use with VRV IV, VRV IV X, VRV AURORA, and T-series Water Cooled heat recovery system components.
- b. These branch selector boxes shall provide individual control and changeover for multiple groups of indoor units.
- c. These branch selector boxes shall allow for Field selectable LEFT/RIGHT/PASS THROUGH piping configuration.
- d. These branch selector boxes shall allow multiple branch selector boxes to be connected downstream of the first Branch selector box in series in series.
- e. These Branch selector boxes when connected in series shall be able to support a total indoor load of up to 230MBH.
- f. The EEV heads and motors used in the branch selector box shall be accessible via a quick access panel without disassembly of the electrical box.
- g. The electrical box of the 4-port branch selector box shall be field re-locatable to left, right, and back side of the main cabinet.
- h. These branch selector boxes shall allow connected indoor units to operate in cooling mode down to -4F without any additional field installed accessories
- i. Labels shall be displayed close to the incoming 3 pipes to facilitate clear identification and eliminate cross piping.
- j. The branch selector boxes shall employ EEV with the ability to control up to 6000 pulses
- k. These selector boxes shall be factory assembled, wired, and piped.
- l. These selector boxes must be mounted indoors.
- m. When simultaneously heating and cooling, the units in heating mode shall energize their subcooling electronic expansion valve.

4. The number of connectable indoor units shall be in accordance with the table below:

BRANCH SELECTOR TYPE	MODEL NUMBER	MAXIMUM CONNECTABLE COOLING CAPACITY	MAXIMUM NUMBER OF CONNECTABLE INDOOR UNITS PER BRANCH

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SINGLE-PORT	BSQ36TVJ	36,000 Btu/h	4
	BSQ60TVJ	60,000 Btu/h	8
	BSQ96TVJ	96,000 Btu/h	8
MULTI-PORT T-SERIES	BS4Q54TVJ	144,000 Btu/h	5
	BS6Q54TVJ	216,000 Btu/h	5
	BS8Q54TVJ	290,000 Btu/h	5
	BS10Q54TVJ	290,000 Btu/h	5
	BS12Q54TVJ	290,000 Btu/h	5
MULTI-PORT FLEX-SERIES	BSF4Q54TVJ	144,000 Btu/h*	5
	BSF6Q54TVJ	216,000 Btu/h*	5
	BSF8Q54TVJ	290,000 Btu/h*	5

* For multiple branch selector box connected in series, refer to the engineering manual for details.

B. UNIT CABINET

1. These units shall have a galvanized steel plate casing.
2. Each cabinet shall house 3 electronic expansion valves for refrigerant control per branch.
3. The cabinet shall contain one subcooling heat exchanger per branch.
4. The unit shall have sound absorption thermal insulation material made of flame and heat resistant foamed polyethylene.
5. Nominal sound pressure levels shall be measured and published on the submittals by the manufacturer. The sound levels must not exceed the values below.
 - a. If an alternative manufacturer is selected, the mechanical contractor shall provide, at their own cost and expense, any additional material and labor to meet the below published sound levels

BRANCH SELECTOR TYPE	MODEL NUMBER	SOUND LEVEL dB(A) OPERATION	SOUND LEVEL dB(A) MAX
SINGLE PORT	BSQ36TVJ	35	40
	BSQ60TVJ	41	45
	BSQ96TVJ	41	45
MULTI-PORT STANDARD T-SERIES	BS4Q54TVJ	38	45
	BS6Q54TVJ	39	47
	BS8Q54TVJ	39	47
	BS10Q54TVJ	40	48
	BS12Q54TVJ	40	48
MULTI-PORT FLEX-SERIES	BSF4Q54TVJ	37	47
	BSF6Q54TVJ	40.5	50
	BSF8Q54TVJ	40.5	50

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C. DIMENSIONS:

1. The branch selector units shall not exceed dimensions stated in the table below.

BRANCH SELECTOR TYPE	MODEL NUMBER	HEIGHT Inches (mm)	WIDTH Inches (mm)	DEPTH Inches (mm)
SINGLE PORT	BSQ36TVJ	8-1/8 (207)	15-1/4 (388)	12-13/16 (326)
	BSQ60TVJ	8-1/8 (207)	15-1/4 (388)	12-13/16 (326)
	BSQ96TVJ	8-1/8 (207)	15-1/4 (388)	12-13/16 (326)
MULTI-PORT STANDARD T-SERIES	BS4Q54TVJ	11-3/4 (298)	14-9/16 (370)	18-15/16 (480)
	BS6Q54TVJ	11-3/4 (298)	22-13/16 (580)	18-15/16 (480)
	BS8Q54TVJ	11-3/4 (298)	22-13/16 (580)	18-15/16 (480)
	BS10Q54TVJ	11-3/4 (298)	32-5/16 (820)	18-15/16 (480)
	BS12Q54TVJ	11-3/4 (298)	32-5/16 (820)	18-15/16 (480)
MULTI-PORT FLEX-SERIES	BSF4Q54TVJ	9 -1/2 (241)	13-3/4 (348)	23-3/4 (603)
	BSF6Q54TVJ	9 -1/2 (241)	23-3/8 (593)	23-3/4 (603)
	BSF8Q54TVJ	9 -1/2 (241)	23-3/8 (593)	23-3/4 (603)

D. REFRIGERANT VALVES:

1. The unit shall be furnished with 3 electronic expansion valves per branch to control the direction of refrigerant flow. The use of solenoid valves for changeover and pressure equalization shall not be acceptable due to refrigerant noise.
2. The refrigerant connections must be of the braze type.
3. In multi-port units, each port shall have its own electronic expansion valves. If common expansion/solenoid valves are used, redundancy must be provided.
4. Multiple indoor units may be connected to a branch selector box with the use of a REFNET™ joint provided they are within the capacity range of the branch selector.
5. These branch selector boxes shall support up to the maximum capacity per port shown in the table below

BRANCH SELECTOR TYPE	MODEL NUMBER	MAXIMUM CAPACITY PER PORT
SINGLE PORT	BSQ36TVJ	36,000 Btu/h
	BSQ60TVJ	60,000 Btu/h
	BSQ96TVJ	96,000 Btu/h

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MULTI-PORT T-SERIES	BS4Q54TVJ	54,000 Btu/h
	BS6Q54TVJ	54,000 Btu/h
	BS8Q54TVJ	54,000 Btu/h
	BS10Q54TVJ	54,000 Btu/h
	BS12Q54TVJ	54,000 Btu/h
MULTI-PORT FLEX-SERIES	BSF4Q54TVJ	54,000 Btu/h
	BSF6Q54TVJ	54,000 Btu/h
	BSF8Q54TVJ	54,000 Btu/h

E. CONDENSATE REMOVAL:

1. The unit shall be hermetically sealed to prevent condensation build up inside the unit, and not require use of a secondary condensate collection pan. A safety device or secondary drain pan shall be installed by the mechanical contractor to comply with the applicable mechanical code, if an alternate manufacturer is selected.

F. ELECTRICAL:

1. The unit electrical power shall be 208/230 volts, 1 phase, 60 hertz.
2. The unit shall be capable of operation within the limits of 187 volts to 255 volts.
3. The minimum circuit amps (MCA) shall be 0.1 and the maximum overcurrent protection amps (MOP) shall be 15.
4. The control voltage between the indoor and condensing unit shall be 16VDC non-shielded 2 conductor cable.

3.5 VRV INDOOR/EVAPORATOR UNITS

FXZQ-TAVJU –VISTA™ 2x2 CASSETTE UNIT:

- A. General: Daikin indoor unit model FXZQ-TAVJU shall be a ceiling cassette fan coil unit, operable with R-410A refrigerant, equipped with an electronic expansion valve, for installation into the ceiling cavity equipped with a decoration panel grille. It shall be available in capacities from 5,800 Btu/h to 18,000 Btu/h. Model numbers are FXZQ05TAVJU, FXZQ07TAVJU, FXZQ09TAVJU, FXZQ12TAVJU, FXZQ15TAVJU, FXZQ18TAVJU to be connected to outdoor unit model RXYQ / RXYMQ / RWEYQ / RWEQ heat pump and REYQ / RELQ / RWEYQ / RWEQ heat recovery model. The decoration panel shall be a four-way air distribution type, with fresh white (Munsell N9.5) or Daikin Silver color, impact resistant with a washable decoration panel. The supply air is distributed via motorized louvers which can be horizontally and vertically adjusted from 0° to 90°. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. The unit shall be equipped with a programmed drying mechanism that dehumidifies while limiting changes in room temperature when used with Daikin remote controls. The indoor units sound pressure shall range from 25.5 dB(A) to 33 dB(A) at low speed measured at 5 feet below the unit.
- B. Indoor Unit:

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1. The Daikin indoor unit FXZQ-TAVJU shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, flare connections, condensate drain pan, condensate drain pump, condensate safety shutoff and alarm, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
2. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
3. Both refrigerant lines shall be fully insulated from the outdoor unit or nearest branch connection into the refrigerant network.
4. The 4-way supply air flow can be field modified to 3-way and 2-way airflow to accommodate various installation configurations including corner installations.
5. Return air shall be through the concentric panel, which includes a resin net mold resistant filter.
6. The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump provides up to 24-13/16" of lift, measured from the drain outlet, and has a built in safety shutoff and alarm.
7. The indoor units shall be equipped with a return air thermistor.
8. The indoor unit will be powered with 208~230V/1-phase/60Hz.
9. The voltage range will be 253 volts maximum and 187 volts minimum.
- C. Unit Cabinet:
 1. The cabinet shall be space saving and shall be located into the ceiling.
 2. Three auto-swing positions shall be available to choose from via field setting.
 3. The airflow of the unit shall have the ability to shut down one or two sides allowing for simpler corner installation.
 4. Fresh air intake shall be possible by way of direct duct installation to the side of the indoor unit cabinet.
 5. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.
- D. Decoration Panel:

The FXZQ-TAVJU series shall be compatible with three optional decoration panels:

 1. VISTA Decoration panel – white (BYFQ60C3W1W).
 - i. The decoration panel shall be a four-way air distribution type and constructed of impact resistant polymer.
 - ii. The decoration panel dimensions shall measure 24-7/16" x 24-7/16" and shall fit into a standard 2x2 ceiling grid with no overlap of adjacent tiles.
 - iii. The four air discharge outlet louvers shall be independently motorized and controllable. Each louver shall have a visual indicator to easily identify the louver and simplify the airflow configuration.
 - iv. The louver outlets shall be capable of closure to allow for 3-way and 2-way air distribution.
 - v. The decoration panel shall be a low profile design, extending 5/16" below the ceiling.
 - vi. The decoration panel shall be compatible with the optional space and presence sensor kit, model BRYQ60A2W.
 - vii. The decoration panel color shall be fresh white (Munsell N9.5).
 2. VISTA Decoration panel – silver and white (BYFQ60C3W1S).

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- i. The decoration panel shall be a four-way air distribution type and constructed of impact resistant polymer.
 - ii. The decoration panel dimensions shall measure 24-7/16" x 24-7/16" and shall fit into a standard 2x2 ceiling grid with no overlap of adjacent tiles.
 - iii. The four air discharge outlet louvers shall be independently motorized and controllable. Each louver shall have a visual indicator to easily identify the louver and simplify the airflow configuration.
 - iv. The louver outlets shall be capable of closure to allow for 3-way and 2-way air distribution.
 - v. The decoration panel shall be a low profile design, extending 5/16" below the ceiling.
 - vi. The decoration panel shall be compatible with the optional space and presence sensor kit, model BRYQ60A2S.
 - vii. The decoration panel color shall be fresh white (Munsell N9.5) and a specialty Daikin Silver color.
- 3. Legacy FXZQ-MVJU9 decoration panel (BYFQ60B3W1).
 - i. The FXZQ-TAVJU cassette body shall be compatible with the legacy 2x2 decoration panel BYFQ60B3W1.
- E. Optional Space and Presence sensor kit:
 - 1. The space and presence sensor shall be color matched to the decoration panel.
 - 2. The sensor kit shall be capable of sensing occupancy within the space and automatically controlling the indoor unit set point in response to the detection of occupancy.
 - 3. The sensor kit shall be capable of automatically adjusting the direction of individual air discharge outlet louvers in response to the detection of occupants in the vicinity of the unit.
 - 4. The sensor kit shall be capable of automatically adjusting the direction of individual air discharge outlet louvers in response to the sensed floor temperature.
- F. Fan:
 - 1. The fan shall be driven by a direct-drive DC motor with statically and dynamically balanced impeller and shall have three user-selectable speeds available: high, medium, and low.
 - 2. The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz with a motor output of 50W.
 - 3. The airflow rate shall be available in high, medium, and low settings.
 - 4. When FXZQ-TAVJU is connected with either the BRC1E73 Navigation Remote Controller or the DCM601A71 I-Touch Manager, the Auto fan mode shall be selectable.
- G. Filter:
 - 1. The return air shall be filtered by means of a washable long-life filter with mildew proof resin.
- H. Coil:
 - 1. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
 - 2. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.

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3. The coil shall be a 2-row cross fin copper evaporator coil with 22 FPI design completely factory tested.
4. The refrigerant connections shall be flare connections and the condensate will be 1 -1/32 inch outside diameter PVC.
5. A condensate pan shall be located under the coil.
6. A condensate pump with a 24-13/16" lift, measured from the drain outlet, shall be located below the coil in the condensate pan with a built in safety alarm.
7. A thermistor will be located on the liquid and gas line.
- I. Electrical:
 1. A separate power supply will be required of 208/230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
 2. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).
 3. Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 feet.
- J. Control:
 1. The unit shall have controls provided by Daikin to perform input functions necessary to operate the system.
 2. The unit shall be compatible with a Daikin Intelligent Touch Manager advanced multi-zone controller.

FXAQ – WALL MOUNTED UNIT

- A. General: Daikin indoor unit FXAQ shall be a wall mounted fan coil unit, operable with refrigerant R-410A, equipped with an electronic expansion valve, for installation onto a wall within a conditioned space. This compact design with finished white casing shall be available in capacities from 7,500 Btu/h to 24,000 Btu/h. Model numbers are FXAQ07PVJU, FXAQ09PVJU, FXAQ12PVJU, FXAQ18PVJU and FXAQ24PVJU to be connected to outdoor unit model RXYQ / RXYMQ / RWEYQ heat pump and REYQ / RWEYQ heat recovery model. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. The unit shall be equipped with a programmed drying mechanism that dehumidifies while limiting changes in room temperature when used with Daikin remote control BRC1E72, BRC1E73 and BRC2A71. A mildew-proof, polystyrene condensate drain pan and resin net mold resistant filter shall be included as standard equipment. The indoor units sound pressure shall range from 31 dB(A) to 41 dB(A) at low speed measured at 3.3 feet below and from the unit.
- B. Indoor Unit:

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1. The Daikin indoor unit FXAQ shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The unit shall have an auto-swing louver which ensures efficient air distribution, which closes automatically when the unit stops. The remote controller shall be able to set five (5) steps of discharge angle. The front grille shall be easily removed for washing. The discharge angle shall automatically set at the same angle as the previous operation upon restart. The drain pipe can be fitted to from either left or right sides.
2. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
3. Both refrigerant lines shall be insulated from the outdoor unit.
4. Return air shall be through a resin net mold resistant filter.
5. The indoor units shall be equipped with a condensate pan.
6. The indoor units shall be equipped with a return air thermistor.
7. The indoor unit will be separately powered with 208~230V/1-phase/60Hz.
8. The voltage range will be 253 volts maximum and 187 volts minimum.
- D. Unit Cabinet:
 1. The cabinet shall be affixed to a factory supplied wall mounting template and located in the conditioned space.
 2. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.
- E. Fan:
 1. The fan shall be a direct-drive cross-flow fan, statically and dynamically balanced impeller with high and low fan speeds available.
 2. The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz with a motor output range 0.054 to 0.058 HP.
 3. The airflow rate shall be available in high and low settings.
 4. The fan motor shall be thermally protected.
- F. Coil:
 1. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
 2. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
 3. The coil shall be a 2-row cross fin copper evaporator coil with 14 fpi design completely factory tested.
 4. The refrigerant connections shall be flare connections and the condensate will be 11/16 inch outside diameter PVC.
 5. A thermistor will be located on the liquid and gas line.
 6. A condensate pan shall be located in the unit.
- G. Electrical:
 1. A separate power supply will be required of 208/230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
 2. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).

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3. Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 feet.
- H. Control:
 1. The unit shall have controls provided by Daikin to perform input functions necessary to operate the system.
 2. The unit shall be compatible with interfacing with a BMS system via optional LonWorks or BACnet gateways.
 3. The unit shall be compatible with a Daikin Intelligent Touch Manager advanced multi-zone controller.
 4. VRV controller provider shall provide web-based interface service for user to view unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling.

END OF SECTION 23 81 27

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SECTION 23 82 39 - TERMINAL HEAT TRANSFER UNITS

1. GENERAL

1.1 SECTION INCLUDES

- A. Unit heaters.

1.2 REFERENCES AND REGULATORY REQUIREMENTS

- A. See Section 23 05 00.

1.3 SUBMITTALS

- A. See Section 23 05 00.

1.4 OPERATION AND MAINTENANCE DATA

- A. See Section 23 05 00.

1.5 QUALIFICATIONS

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

1.6 DELIVERY, STORAGE AND HANDLING

- A. See Section 23 05 00.

1.7 SEQUENCING AND SCHEDULING

- A. See Section 23 05 00.
- B. Install cabinet unit heaters only after walls and ceiling are finished and painted.

2. PRODUCTS

2.1 SWINE UNIT HEATERS

- A. High temp aluminized steel burn chamber

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- B. Standard adjustable “Y” heat deflector
- C. Diagnostic lights for troubleshooting ease
- D. 1/3 HP totally enclosed thermally protected motor with sealed bearings
- E. On/Off toggle switch ambient temperature.
- F. Back-up safety sail switch
- G. High limit safety switch (manual reset)

2.2 GAS-FIRED UNIT HEATERS

- A. Description: Factory assembled, piped, and wired, and complying with ANSI Z83.8/CSA 2.6.
- B. Fuel Type: Design burner for natural gas having characteristics same as those of gas available at Project site.
- C. Housing: Steel, with integral draft hood and inserts for suspension mounting rods.
- D. External Casings and Cabinets: Powder coated over corrosion-resistant-treated surface.
- E. Suspension Attachments: Reinforce suspension attachments at connection to fuel-fired unit heaters.
- F. Heat Exchanger: Stainless steel.
- G. Burner Material: Stainless steel.
- H. Unit Fan: Aluminum propeller blades riveted to heavy-gage steel spider bolted to cast iron hub, dynamically balanced, and resiliently mounted.
- I. Fan-Blade Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
- J. Motors: Totally enclosed with internal thermal-overload protection.
- K. Controls: Regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
- L. Gas Control Valve: Single-stage

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- M. Ignition: Electronically controlled electric spark with flame sensor.
- N. Fan Thermal Switch: Operates fan on heat-exchanger temperature.
- O. Control transformer.
- P. High Limit: Thermal switch or fuse to stop burner.
- Q. Thermostat: 2-stage, wall-mounting type with fan on switch.
- R. Discharge Louvers: Independently adjustable horizontal blades.
- S. Vertical discharge louvers.
- T. Unit-mounted thermostat bracket.
- U. Power Venter: Centrifugal aluminized steel fan, with stainless steel shaft; 120-V ac motor.
- V. Concentric, Terminal Vent Assembly: Combined combustion-air inlet and power-vent outlet with wall or roof caps. Include adapter assembly for connection to inlet and outlet pipes, and flashing for wall or roof penetration.

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. Hang unit heaters from building structure, with pipe hangers anchored to building, not from piping. Mount as high as possible to maintain greatest headroom unless otherwise indicated.
- C. Install cabinet unit heaters and fan coil units as indicated. Coordinate to assure correct recess size for recessed units.
- D. Protect units with protective covers during balance of construction.

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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. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

END OF SECTION 23 82 39

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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).

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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

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- 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 5 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.

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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

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- 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.

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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

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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

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- 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

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MOTOR TEST REPORT

DATE: _____

SHEET NO. _____ OF _____

PROJECT NAME: _____

PROJECT NUMBER: _____

DESIGNATION						
LOCATION						
HORSEPOWER						
NEMA STARTER SIZE						
MAXIMUM HEATER AMPS						
MEASURED	PHASE			PHASE		
CONDITIONS	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	PHASE			PHASE		
CONDITIONS	A	B	C	A	B	C
ACTUAL MOTOR CURRENT						
NAMEPLATE MOTOR CURRENT						
NO LOAD VOLTAGE						
FULL LOAD VOLTAGE						

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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									

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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

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- 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 |

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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.

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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:

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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 |

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E.	Convenience outlets prong	18" mounted vertically with ground 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

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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

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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

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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

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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 not be supported from the leg of pre-cast pre-stressed concrete.

END OF SECTION 26 05 01

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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.

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- 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. Joselyn Mfg. and Supply Co.
- 7. O-Z/Gedney Co.
- 8. Pyle National Co.
- 9. Thomas and Betts Co.

2.2 WIRE, CABLE, AND CONNECTORS

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- 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:

<u>PHASE</u>	<u>120/208 VOLT</u>	<u>277/480 VOLT</u>
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.

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- 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.

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- 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.

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- 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

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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

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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.**

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- 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

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- 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,

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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.

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- 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.

RACEWAYS

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- 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.

	<u>Location</u>	<u>Maximum Allowance</u>
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.	

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- 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.

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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. 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

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- 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.

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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 260800 - ELECTRICAL COMMISSIONING REQUIREMENTS

PART 1 GENERAL

1.1 WORK INCLUDES

- A. Validation of proper installation of Divisions 26 systems and equipment
- B. Systems and equipment testing and startup
- C. Equipment performance verification
- D. Functional testing of control systems
- E. Documentation of tests, procedures and installations

1.2 SCOPE INCLUDES

- A. Systems to be commissioned include the following:
 - 1. Power Distribution [Panelboards and Transformers]
 - 2. Emergency Power
 - 3. Lighting Controls

1.3 RELATED DOCUMENTS

- A. Commissioning Plan - This plan is part of the Contract Documents and outlines many responsibilities, procedures and tasks throughout the commissioning process.
- B. Section 019113 – General Commissioning Requirements
- C. Section 230800 – Mechanical Commissioning Requirements
- D. Division 26 Sections - Individual Sections stipulate installation, startup, warranty and training requirements for the system or device specified in that Section.

1.4 REFERENCES

- A. ASHRAE Guideline 0-2013: The HVAC Commissioning Process.
- B. ANSI/NEBB S110-2019 - Whole Building Technical Commissioning of New Construction

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1.5 GENERAL DESCRIPTION

- A. Commissioning is a process to assure all building systems are installed and perform interactively according to the design intent; the systems are efficient, cost effective and meet the Owner's operational needs; the installation is adequately documented. Commissioning serves as a tool to minimize post-occupancy operational problems. It establishes testing and communication protocols in an effort to advance building systems from installation to fully optimized operation.
- B. The Commissioning Authority will work with the Contractor and Design Engineer to coordinate, oversee, and document the commissioning process during the Construction Phase of this project.
- C. This Section defines responsibilities of the Contractor to facilitate the commissioning process particularly during the Construction Phase of the project.

1.6 DEFINITIONS

- A. Refer to specification section 019113 for definitions related to the commissioning process.

1.7 DOCUMENTATION

- A. Contractor shall send Commissioning Authority one copy of the following per the procedures specified in other sections of the Specification:
 - 1. Shop drawings and product data related to systems and equipment to be commissioned on this project. CxA will review and incorporate comments via the Design Engineer.
 - 2. Initial draft of equipment startup plan checklists along with manufacturers' startup procedures. CxA will assist in development and recommend approval.
 - 3. System Test Reports. CxA will review and compile prior to FPT.
 - 4. System certificate of readiness including completed equipment startup forms along with the manufacturers' field or factory performance test documentation. CxA will review and approve prior to FPT.

1.8 SEQUENCING AND SCHEDULING

- A. Systems can be in various stages of the commissioning process where appropriate, in order to expedite close out of the facility. The CxA and Contractor shall cooperate to schedule Cx tasks to minimize the duration of Cx activities. Sequential priorities shall be followed per the Cx Plan.
- B. Commissioning Schedule - Contractor shall incorporate the commissioning process into the project schedule. Startup, TAB and FPT shall be itemized as applicable for each system. Durations for each task shall be coordinated with the CxA.

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1.9 COORDINATION MANAGEMENT PROTOCOLS

- A. Coordination responsibilities and management protocols relative to Cx are initially defined in the Cx Plan but will be refined and documented at the commissioning scoping meeting. Contractor shall have input to the protocols and all parties will commit to scheduling obligations. The CxA will record and distribute notes from the meeting.

1.10 CONTRACTOR RESPONSIBILITIES

- A. Construction Phase
1. Include commissioning requirements in price and plan for work.
 2. Attend scoping and coordination meetings scheduled by the CxA.
 3. Remedy deficiencies identified during the construction period.
 4. Prepare and submit required draft forms and equipment information requested by the CxA. Typically, this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any owner-contracted tests, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation, start-up and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the CxA.
 5. Assist in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
 6. Provide limited assistance to the CxA in preparing the specific functional performance test procedures. Contractors shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
 7. Where functional testing is to be executed by the system/equipment provider (see “Systems/Equipment to be Commissioned”) the Contractor, with the CxA’s assistance, will develop final functional test checklists for each system, subsystem, or equipment including interfaces and interlocks, and include a separate entry, with space for comments, for each item to be tested.
 8. Thoroughly complete and inspect installation of systems and equipment in accordance with the Contract Documents, reference or industry standards, and specifically Part 3 of this Section.
 9. Startup systems and equipment prior to verification and performance testing by the CxA. Startup procedures shall be in accordance with Contract Documents, reference or industry standards, and specifically Part 3 of this Section.
 10. Record startup and test procedures on startup forms and checklists and certify the systems and equipment have been started and tested in accordance with the Contract Documents,

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reference or industry standards, and specifically Part 3 of this Section. Each form shall be signed and dated by the individual responsible for the startup or test.

11. Complete pre-approved startup checklists and submit along with other installation certification documentation such as certificate of readiness, warranties, test results, etc.
12. Schedule and coordinate Cx efforts required by appropriate subcontractors and vendors.
13. Demonstrate the systems as specified.
14. Certify systems have been installed and are operating per Contract Documents through certificates of readiness.
15. Maintain an updated set of record documentation.
16. Copy CxA on indicated documentation.
17. Conduct equipment operation, maintenance, diagnosis and repair training as required by the respective section of the Specifications.

B. Acceptance Phase

1. Assist CxA in verification and performance testing. Assistance will generally include the following:
 - a. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
 - b. Manipulate systems and equipment to facilitate testing.
 - c. Manipulate control systems to facilitate verification and performance testing.
2. Correct any work not in accordance with Contract Documents and non-conformances included in the commissioning issues log.

C. Warranty Phase

1. Provide warranty service.
2. Correct any deficiencies identified.
3. Update record documentation to reflect any changes made throughout the Warranty Phase.

1.11 CONTRACTOR NOTIFICATION

- A. Contractor shall completely install, thoroughly inspect, startup systems and equipment. All activities shall be documented on specified forms. Contractor shall notify Design Engineer, Owner and CxA via the certification of readiness that systems are complete and ready for verification and functional performance testing.

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- B. Contractor shall notify CxA at least 10 business days in advance of any tests or startups. CxA shall witness selected tests and startups.

1.12 STARTUP CHECKLISTS

- A. Startup checklists for each type of equipment and system shall be submitted to CxA for approval prior to startup. The forms shall be designed by the appropriate subcontractors or vendors to meet the requirements of the Contract Documents. Forms shall be developed for the specific equipment being installed for this project.
- B. Startup checklists shall generally include the following for each (as applicable):
 - 1. Project specific designation, location and service
 - 2. Pertinent nameplate data
 - 3. Indication of the party performing the test
 - 4. Field for signature of the startup technician along with the date
 - 5. Clear explanation of the inspection, test, measurement, etc. with a pass/fail indication and a record of measurement parameters
 - 6. Checklist space that proper maintenance clearances have been maintained
 - 7. Checklist space indicating that any required special tools and/or spare tools were turned over to the Owner
 - 8. Checklist space indicating that required prerequisite equipment and systems were successfully started.
- C. Startup checklists shall incorporate the manufacturer-specified procedures. Contractor shall compile the startup and checkout procedures indicated in the manufacturer's documentation prior to designing the forms. Include specified acceptance criteria as applicable. The manufacturer's startup and checkout procedures shall be submitted to the CxA along with the draft startup checklists.
- D. Completed startup plans for all pieces of equipment included in a system shall be submitted to CxA prior to verification and performance testing.
- E. See specification 019113 for additional information regarding Startup Checklists.

1.13 FUNCTIONAL PERFORMANCE TESTING

- A. Participation: CxA will coordinate, test and/or witness functional performance tests after the successful startup and documentation of systems and equipment is complete. Contractor shall assist, as described above, with manipulation of the systems or equipment; provision of supporting equipment or materials (lifts, ladders, specialty test equipment, etc.); and on the spot remediation of minor identified deficiencies.

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- B. Detailed Test Forms: CxA will prepare detailed testing procedures and forms to conduct and document the FPT. These will be developed during the Construction Phase and completed during the Acceptance Phase.
- C. Test Documentation: CxA will record test results on the forms developed for the testing. CxA will Pass or Fail the testing and record the date and time of the test. Deficiencies shall clearly indicate when the test has failed. CxA shall recommend acceptance of the system or component after all related testing is successfully complete.
- D. Deficiencies and Retesting: When deficiencies are identified during testing, depending on their extent or magnitude, they can be corrected during the test and the testing can continue to successful completion. Significant deficiencies will fail the test and require retesting of the affected portions of the test. The CxA will subsequently track the resolution of the deficiency via the Project Deficiency List. All tests shall be repeated until successful completion.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

3.1 GENERAL

- A. This Section outlines specific startup, checkout, and functional testing requirements for systems and equipment. Generally, these procedures are the direct responsibility of the Contractor as a basic element of validating that the installation is correct. These requirements along with those specified in the individual Section provide a minimum guideline for development of startup procedures, checklists and tests. Contractor shall synthesize these requirements with that of the manufacturer's and/or applicable codes and standards to develop specific and itemized startup procedures specific to that installed on this project.
- B. Refer to all Division 26 Specifications for tests performed on installed equipment and systems.

3.2 STARTUP

- A. The contractor shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in 019113. The Contractor has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning authority or Owner.
- B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CxA and Contractor. Beginning system testing before full completion does not relieve the Contractor from

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fully completing the system, including all startup plan checklists as soon as possible.

3.3 STARTUP/CHECKOUT

- A. Verify that equipment testing work is complete before starting functional performance of power equipment.
- B. Inspect equipment and confirm that it is clean and ready for operation. All shipping tags removed, nameplates installed and equipment manuals in place.
- C. Verify all equipment labeling corresponds with drawings and indices and meets required Specifications. Correct any deficiencies for electrical systems.

3.4 POWER DISTRIBUTION – STARTUP/CHECKOUT

- A. Overcurrent protective device settings coordinated and adjusted per the study results.
- B. System in place and tested, including all components indicated.
- C. Connected to utility company power system on a permanent basis.
- D. Wiring installed in conduits or other raceways.
- E. System checked for unwanted grounds, short circuits or open circuits.
- F. Ground installed as indicated, including transformers.
- G. Equipment connections properly torqued.
- H. Equipment, where indicated, on housekeeping pads.
- I. Equipment cleaned and shipping blocks removed.
- J. Equipment labeled.
- K. Boxes and nameplates meet color coding requirements.

3.5 EMERGENCY POWER DISTRIBUTION – STARTUP/CHECKOUT

- A. System in place and tested, including all components indicated.
- B. Facility shall be connected to utility company power system on a permanent basis before emergency checklist is addressed.

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- C. Wiring installed in conduits or other raceways.
- D. System checked for unwanted grounds, short circuits or open circuits.
- E. Grounds installed as indicated, including transformers.
- F. Ground fault settings made.
- G. Equipment connections properly torqued.
- H. Equipment, where indicated, on housekeeping pads.
- I. Equipment cleaned and shipping blocks removed.
- J. All ATS delay and timer settings are programmed.
- K. Equipment labeled.
- L. Boxes and nameplates meet color coding requirements.
- M. Proper phase rotation coordinated between emergency and normal sources

3.6 LIGHTING CONTROLS – STARTUP/CHECKOUT

- A. System in place and tested, including all components indicated.
- B. Wiring installed in conduits or other raceways.
- C. System check for unwanted grounds, short circuits or open circuits.
- D. Grounds installed as indicated.
- E. Equipment labeled.
- F. Boxes and nameplates meet color coding requirements.
- G. Connected to emergency power system where required.
- H. New portion of system connected and interfaced with existing lighting control system.
- I. Verify system has been inspected and given approval by jurisdictional authority.

3.7 FUNCTIONAL TESTING

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- A. This section specifies the functional testing requirements for Division 26 systems and equipment. From these requirements, the Commissioning Authority (CxA) shall develop step-by-step procedures to be executed by the Contractors or the Commissioning Authority. The general functional testing process, requirements and test method definitions are described in Section 019113. The test requirements for each piece of equipment or system contain the following:
1. The contractors responsible to execute the tests, under the direction of the CxA
 2. A list of the integral components being tested
 3. Startup plan checklists associated with the components
 4. Functions and modes to be tested
 5. Required conditions of the test for each mode
 6. Special procedures
 7. Required monitoring
 8. Acceptance criteria
- B. PREREQUISITES
1. The following applicable generic prerequisite checklist items are required to be completed and submitted with the equipment/system certificate of readiness and checked off by CxA prior to functional testing.
 2. All related equipment has been started up and startup plan checklists submitted and approved ready for functional testing.
 3. All control system functions for this and all interlocking systems are programmed and operable per contract documents, including final setpoints and schedules with debugging, loop tuning and sensor calibrations completed.
 4. Test and balance (TAB) complete and approved for the air and hydronic systems
 5. All A/E punchlist items for this equipment corrected
 6. Schedules and setpoints provided to the CxA
 7. False loading equipment, system and procedures ready
 8. Sufficient clearance around equipment for servicing
- C. MONITORING
1. Monitoring is a method of testing as a stand-alone method or to augment manual testing.
 2. All points listed in the required monitoring section of the test requirements which are control system monitored points shall be trended by the controls contractor. Other points shall be monitored by the CxA using dataloggers. At the option of the CxA, some control system monitoring may be replaced with datalogger monitoring. At the CxA's request, the controls contractor shall trend up to 20% more points than listed herein at no extra charge.

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3. Trend output data must be in an ASCII delimited text file with time continuous down left column and point values in column(s) to the right.
4. All trends for points of a group must start at the same moment in time, unless specifically approved otherwise with the commissioning agent.

3.8 NORMAL POWER SYSTEMS FPT

- A. Parties Responsible to Execute Functional Test
 1. Electrical contractor: perform functional testing
 2. CxA: to witness, direct and document testing.
 3. Equipment manufacturer's representative, as required.
 4. Owner's Representative
 5. Owner's maintenance staff, as desired.
- B. Prerequisites: The applicable prerequisite checklist items listed in paragraph 3.7.B shall be listed on each certificate of readiness form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the startup plan checklists previously completed by the installer, before the beginning of functional testing.
- C. Functions / Modes Required to be Tested
 1. Activate system by connection to utility power.
 2. Verify voltages and amperes at meters on switchgear.
 3. Verify voltages and amperes at switchgear, switchboards, motor control centers, panelboards, and transformers, both primary and secondary.
 4. Verify voltages and amperes at mechanical motors and other major pieces of equipment.
- D. Results: If specified equipment performance is not achieved, the Contractor shall have corrections made and reschedule Functional Performance Test as soon as possible after corrective work is completed.
- E. Acceptance Criteria
 1. For the conditions, sequences and modes tested, the system, integral components, and related equipment respond to varying loads and changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.

END OF REQUIREMENTS FOR POWER SYSTEMS TEST

3.9 EMERGENCY POWER SYSTEMS FPT

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- A. Parties Responsible to Execute Functional Test
 - 1. Electrical contractor: perform functional testing
 - 2. CxA: to witness, direct and document testing.
 - 3. Equipment manufacturer's representative, as required.
 - 4. Owner's Representative
 - 5. Owner's maintenance staff, as desired.
- B. Prerequisites: The applicable prerequisite checklist items listed in paragraph 3.5.B shall be listed on each certificate of readiness form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the startup plan checklists previously completed by the installer, before the beginning of functional testing.
- C. Functions / Modes Required to be Tested
 - 1. Activate system by manual transfer from utility power.
 - 2. Demonstrate automatic transfer of power.
- D. Results: If specified equipment performance is not achieved, the Contractor shall have corrections made and reschedule Functional Performance Test as soon as possible after corrective work is completed.
- E. Acceptance Criteria
 - 1. For the conditions, sequences and modes tested, the system, integral components, and related equipment respond to varying loads and changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.

END OF REQUIREMENTS FOR EMERGENCY POWER SYSTEMS TEST

3.10 LIGHTING CONTROL SYSTEM FPT

- A. Parties Responsible to Execute Functional Test
 - 1. Electrical contractor
 - 2. CxA: to witness, direct and document testing.
 - 3. Equipment manufacturer's representative, as required.
 - 4. Owner's Representative
 - 5. Owner's maintenance staff, as desired.
- B. Prerequisites: The applicable prerequisite checklist items listed in paragraph 3.6.B shall be listed on each certificate of readiness form and checked off prior to functional testing. The commissioning agent will also spot-check misc. items and calibrations on the startup plan

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checklists previously completed by the installer, before the beginning of functional testing.

C. Functions / Modes Required to be Tested

1. Demonstrate operation of lighting control system per specifications including the following:
 - a. Control switches
 - b. Dimming performance
 - c. Verify tie-in and proper system remote operation
 - d. Verify system function upon loss of power

D. Results: If specified equipment performance is not achieved, the Contractor shall have corrections made and reschedule Functional Performance Test as soon as possible after corrective work is completed.

E. Acceptance Criteria

1. For the conditions, sequences and modes tested, the system, integral components, and related equipment respond to varying loads and changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice.

END OF REQUIREMENTS FOR LIGHTING CONTROL SYSTEM TEST

END OF SECTION 26 08 00

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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.

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- 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

PANELBOARDS

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- 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

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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

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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, I_{2tin} and I_{2tout}, 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, I_{2tin} and I_{2tout}

- 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.

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- 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

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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

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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

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- 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. 208Y/120V, 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

DUAL PURPOSE DOCKING STATION

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- 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

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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 than 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."

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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.

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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

WIRING DEVICES

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- 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

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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

MOTOR CONTROLLERS

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- 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.

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- 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 than 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.

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- 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.

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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 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.

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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 2 weeks 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: **208** Volts AC, Three phase, 4-wire, 60 hertz.
2. The generator set shall be rated at **250 kW, 312.5 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.

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4. Motor starting capability shall be a minimum of 1896kVA. 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 15%.
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 1860 cubic inches, with 12 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.

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- 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.

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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.

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- 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.

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- 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

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- 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:

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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 (verify with Mechanical Controls Contractor to verify compatibility) 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.

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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 for communication of generator system alarms/status.**

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:

<u>Condition</u>	<u>Lamp Color</u>	<u>Audible Alarm</u>
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

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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 86dB 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.

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- 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.
- 2.6 AUTOMATIC TRANSFER SWITCHES – OPEN TRANSITION/NON-BYPASS ISOLATION TYPE
- A. General
 - 1. Furnish and install automatic transfer switch(es) with number of poles, amperage, voltage and withstand ratings as shown on the plans. Each system shall be the product of one manufacturer.
 - 2. Transfer switches shall be for 3 phase, 4-wire service with switched neutrals.
 - B. Mechanically-held transfer switch:

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1. The transfer switch unit shall be electrically operated and mechanically held. The electrical operator shall be a single-solenoid mechanism, momentarily energized to minimize power consumption and heat generation. The switch shall be positively locked and unaffected by voltage variations or momentary outages so that contact pressure is maintained at a constant value and temperature rise at the contacts is minimized for maximum reliability and operating life. The switch shall be mechanically interlocked to ensure only one of two possible positions - normal or emergency.
2. All main contacts shall be silver composition. Switches rated 600 amperes and above shall have segmented, blow-on construction for high withstand current capability and be protected by separate arcing contacts. ATS' utilizing components of molded-case circuit breakers, contactors or parts thereof which have not been intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.
3. Inspection of all contacts (movable and stationary) shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. A manual operating handle shall be provided for maintenance purposed. The handle shall permit the operator to stop the contacts at any point throughout the entire travel to properly inspect and service the contacts when required.

C. Microprocessor Control Module

1. The control module shall direct the operation of the transfer switch. The module's sensing and logic shall be controlled by a built-in microprocessor for maximum reliability, minimum maintenance, and inherent digital communications capability. The control module shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the control module to be disconnected from the transfer switch for routine maintenance.
2. The control module shall be completely enclosed with a protective cover and be mounted separately from the transfer switch unit for safety and ease of maintenance. Sensing and control logic shall be provided on plug-in printed circuit boards for maximum reliability. Interfacing relays shall be industrial control grade plug-in type with dust covers. All relays shall be identical to minimize the number of unique parts.
3. The control panel shall meet or exceed the voltage surge withstand capability in accordance with IEEE Standard 472-1974 (ANSI C37.90a-1974) and the impulse withstand voltage test in accordance with the proposed NEMA Standard ICS 1-109.

D. Engine Generator Exerciser Timer:

1. An engine generator-exercising timer shall be built in to the ATS control module and shall include a selector switch to select exercise with or without load transfer. The exerciser shall be solid-state for maximum reliability and minimum maintenance and shall be programmable to enable exercise for 1 minute to 24 hours per day for 0 to 7 days per week. Exercise settings shall be set by pushbutton and a digital display shall be provided to indicate settings. A replaceable, built-in battery shall be provided to enable the exerciser to continue to operate for up to two weeks without external power. A built-in battery charger shall extend battery life to at least five years. Loss of the battery shall not disable the exercise function as long as normal power is present.

E. Inphase Monitor:

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1. An inphase monitor shall be built in to the ATS and shall control transfer so that motor load inrush currents do not exceed normal starting currents, to avoid nuisance tripping of circuit breakers and possible mechanical damage to motor couplings.
2. The inphase monitor shall operate without external control of electrical loads and without any external control of the power sources.
3. The monitor shall compare the phase relationship and frequency difference between the normal and emergency sources and permit transfer the first time the sources are within 15 electrical degrees and only if transfer can be accomplished within 60 electrical degrees as determined by monitoring the frequency difference. Inphase transfer shall be accomplished if both sources are within 2 Hertz of nominal frequency and 70% or more of nominal voltage.

F. Operation:

1. Three-phase control shall be provided for three-phase power sources. Three-phase controls shall include a selector switch to enable temporary operation on single-phase power sources.
2. The voltage of each phase of the normal source shall be monitored, with pickup adjustable from 85 to 100% and dropout adjustable from 75 to 98% of pickup setting, both in increments of 1%, and shall be fully field-adjustable without the use of any tools, meters or power supplies. Repetitive accuracy of settings shall be +/- 2% or better over an operating temperature range of -20°C to 70°C. Factory set to pick up at 90% and dropout at 85%.
3. Single-phase voltage sensing of the emergency source shall be provided, with a pickup adjustable from 85 to 100% (and dropout fixed at 84 to 86% of pickup), and frequency sensing with pickup adjustable from 90 to 100% (and dropout fixed at 87 to 89% of pickup).
4. Both pickup settings shall be fully field-adjustable in 1% increments without the use of any tools, meters or power supplies. Repetitive accuracy of settings shall be +/- 2% or better over an operating temperature range of -20°C to 70°C. Factory set to pick up at 90% voltage and 95% frequency.
5. The control module shall include four time delays that are fully field-adjustable in increments of at least 13 steps over the entire range as follows:
 - a. Time delay to override momentary normal source outages to delay all transfer switch and engine starting signals. Adjustable from 0 to 6 seconds. Factory set at 1 second.
 - b. Transfer to emergency time delay. Adjustable from 0 to 5 minutes. Factory set at 0 minutes.
 - c. Retransfer to normal time delay. Time delay is automatically bypassed if emergency source fails and normal source is acceptable. Adjustable from 0 to 30 minutes. Factory set at 30 minutes.
 - d. Unloaded running time delay for emergency engine generator cooldown. Adjustable from 0 to 60 minutes. Factory set at 5 minutes.

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6. A set of DPDT gold-flashed contacts rated 10 amps, 32VDC shall be provided for a low-voltage engine start signal when the normal source fails. The start signal shall prevent dry cranking of the generator by requiring the generator to reach proper output, and to run for the duration of the cooldown setting, regardless of whether the normal source restores before the generator is ready to accept the load.
- G. A momentary-type test switch shall be provided to simulate a normal source failure. Also, terminals for a remote contact which opens to signal the ATS to transfer to emergency and terminals for remote contacts which open to inhibit transfer to emergency and/or re-transfer to normal shall be provided.
- H. A visual position indicator shall be provided to indicate switch position. Pilot lights shall indicate availability of power sources and automatic transfer switch position. A prominent and detailed instruction plate shall be furnished.
- I. One set of auxiliary contacts shall be provided rated 10 amps, 208 VAC, consisting of one contact closed when the ATS is connected to normal and one contact closed when the ATS is connected to emergency.
- J. Output terminals to signal the actual availability of the normal and emergency sources, as determined by the voltage sensing pickup and dropout settings for each source, shall be provided.
- K. The ATS shall be provided with a Modbus RTU or Native BACNet communication network interface module for communication of transfer switch alarms/status.**
- L. Compliance with Codes and Standards:
 1. The ATS shall conform to the requirements of:
 - a. UL 1008 - Standard for Automatic Transfer Switches
 - b. NFPA 70 - National Electrical Code, including use in emergency and standby systems in accordance with Articles 517, 700, 701, and 702.
 - c. NFPA 99 - Essential Electrical Systems for Health Care Facilities
 - d. NFPA 110 - Standard for Emergency and Standby Power Systems
 - e. IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems (Orange Book)
 - f. IEEE Standard 241 - IEEE Recommended Practice for Electric Power Systems in Commercial Buildings (Gray Book).
 - g. NEMA Standard ICS2-447 - AC Automatic Transfer Switches
 - h. IEC - Standard for Automatic Transfer Switches
 2. The ATS shall be UL listed in accordance with UL 1008. Requirements of UL 1008 include but are not limited to as follows:

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1. Rated in amperes for total system transfer including control of motors, electric-discharge lamps, electric-heating and tungsten-filament lamp loads as referred to in Paragraph 38.13 of UL 1008.
2. Switches rated 400 amperes and below shall be suitable for 100% tungsten-filament lamp load. Switches rated above 400 amperes shall be suitable for 30% tungsten-filament load.
3. Overload and endurance at 208 volts AC per Tables 25.1, 25.2, 27.1, and 27.2 of UL 1008 when enclosed according to Paragraph 1.6.
4. Temperature rise tests after the overload and endurance tests to confirm the ability of the transfer switches to carry their rated current within the allowable temperature limits.
5. No welding of contacts. Transfer switch must be electrically operable to alternate source after the withstand current tests.
6. Dielectric tests at 1960 volts, rms, minimum after the withstand current test.

M. Withstand Current Ratings:

1. The ATS shall be rated to withstand **42,000 amps** rms symmetrical short circuit current at the ATS terminals with the type of overcurrent protection shown on the plans.

N. Tests and Certification

1. All production units shall be subjected to the following factory tests:
 - a. The complete ATS shall be 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 switch shall be subjected to a dielectric strength test per NEMA Standard ICS1-109.21.

O. Configuration and Manufacturer:

1. The ATS shall be furnished in a NEMA Type 1 enclosure unless otherwise shown on the plans.
2. **Switch shall not require rear access. Access for installation and maintenance shall be from front only.**
3. **The Open Transition type ATS shall be an ASCO model 7000 or approved equivalent. Equivalent equipment by Cummins or Russ Electric is acceptable.**

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.

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- 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

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- 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, if necessary.

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- 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.

END OF SECTION 26 32 13

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SECTION 26 41 00 – LIGHTNING PROTECTION SYSTEM

PART 1. GENERAL

1.1 SUMMARY

- A. **The existing portion of the South Farm Swine Research Facility 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.

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- 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.

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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 be 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.

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- 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.

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- 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 lightning 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.

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- 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

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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 manufacture 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

LIGHTING

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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

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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.

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- 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

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- 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

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- 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 required 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.

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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

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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 (Notifier) SHALL BE EXPANDED AS NECESSARY TO SERVE THE AREA OF RENOVATION. THE FOLLOWING SPECIFIES THE PERFORMANCE REQUIREMENTS 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. Notifier
- 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

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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.

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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.

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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

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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.

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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.

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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

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- 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

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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 (**WHITE in 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

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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.

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- 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.

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- 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

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**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

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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.

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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 31 10 00
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.

SITE CLEARING

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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.

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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.

SITE CLEARING

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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 31 20 00 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 filling 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.

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- 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.

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.

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.

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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:

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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. 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 and pavement areas.
 2. Acceptable material:
 - a. MoDOT Type 5 aggregate.
 - b. Excavated on-site or off-site borrow high plasticity clay material blended with lime or ASTM C618 Class C fly ash to produce a low volume change material.
 - 1) Blending rate shall be approved by testing agency, with estimated rates as follows.
 - a) Hydrated lime: 5 percent on a dry weight basis.
 - b) Fly ash: 15 percent on a dry weight basis.
 - 2) Blending procedures shall be as directed by testing agency.
- D. 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: Clean crushed stone or gravel, free of Shale, clay, friable material, and debris, complying with ASTM C33 Size No. 57.
- E. Pavement Subbase Course:
1. Definition: Granular base used beneath concrete pavement and other pavements indicated on Drawings.
 2. Acceptable materials: MoDOT Type 1 Aggregate.

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- F. Bedding Materials: Type 1 aggregate per MoDOT Standard Specification for Highway Construction, Section 1007.
- G. Trench Backfill Materials:
 - 1. Slab on grades: MoDOT Type 5 aggregate.
 - 2. Pavement areas: MoDOT Type 5 aggregate.
 - 3. Other areas: General Fill Material or other materials specified under this Section at locations specified or indicated on Drawings.
- H. Manual 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.
- I. 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.

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- 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. Use of explosives is not permitted.
- B. 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.
- C. Perform excavation to the lines and grades indicated on Drawings within a tolerance of 0.10 foot.

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1. Extend excavations a sufficient distance from structures for placing and removing concrete formwork, installing services and other construction, and for inspections.
- D. 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".
- E. Perform Work in a manner and sequence that will provide drainage at all times and that will prevent surface water from draining into excavations.
- F. Protect subgrades and foundation soils against freezing temperatures and frost.
 1. Provide protective insulation materials as necessary.
- G. When excavating through roots, perform Work by hand cutting roots with sharp axe.
- H. Excavation cut shall not interfere with normal 45 degree bearing splay of foundations.
- I. 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.
- J. 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.
- K. 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.
- L. Backfill and compact unauthorized over-excavations 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.
- M. Stockpile excavation material which testing agency has approved for reuse.
 1. Stockpile soil materials without intermixing soil materials with different consistencies and gradation.

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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.
- N. Remove unacceptable excavation material from Site, at no increase in Contract Sum or extension of Contract Time.
- O. Hand trim excavations.
1. Remove loose matter.
- P. 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. Use of explosives is not permitted.
- B. 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.
- C. Excavate trenches to gradients, lines, depths, and elevations indicated on Drawings, within a tolerance of 0.10 foot.
- D. 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".
- E. 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.
- F. Perform Work in a manner and sequence that will provide drainage at all times and that will prevent surface water from draining into trenches.
- G. Protect subgrades against freezing temperatures and frost.
- H. Provide protective insulation materials as necessary.
- I. When excavating through roots, perform Work by hand cutting roots with a sharp axe.
- J. Excavation cut shall not interfere with normal 45 degree bearing splay of foundations.

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- K. Excavate trenches to uniform width, sufficiently wide to enable installation of utilities and to allow safe inspection of installed utilities.
- L. 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.
- M. 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.
- N. 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.
- O. 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.
- P. 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:

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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.

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- b. Compact to a minimum of 95% of the material's maximum Standard Proctor dry density with a moisture content between 0 and +4 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 0 and +4 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 0 and +4 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.

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- a. Compact to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between 0 and +4 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 0 and +4 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 0 and +4 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

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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.

B. Excavation for footings and foundations bearing on soil material shall not occur until completion of building slab-on-grade subgrade preparation and utility trenches backfill specified in this section is complete.

1. Excavate existing subgrade material to a depth equal to the depth of the footing or 3 feet, whichever is greater.
 - a. Any unsuitable materials identified by the Geotechnical Engineer, such as desiccated clay or clayey shale below the footings within 2 feet or soft clay within 3 feet, shall be removed and replaced with engineered controlled fill. The fill shall also extend half the width of the footing or 2 feet, whichever is greater, beyond the perimeter of the footing. Compaction of the fill shall be to a minimum dry density equal to 95% of the maximum dry density as determined by ASTM D698 at a moisture content between 0 and +4 percent above optimum.
 - b. All interior footings shall be placed a minimum of 2.0 feet below the finished floor grade. All exterior footings shall be placed a minimum of 3.0 feet below the lowest adjacent exterior finished grade for frost protection.

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- c. Isolated column footings shall have a minimum width of 30 inches. Formed continuous wall footings shall have a minimum width of 16 inches. Earth formed trench footings shall have a minimum width of 12 inches.
- d. All footing excavations shall be free of water and loose materials. Concrete placement shall occur as soon as practical, preferably the same day, after the excavation for footings.
- e. Upon completion of the footing trench excavation, bearing capacity of the subgrade shall be verified using a proper field strength test, and approved by the geotechnical engineer prior to the placement of rebar. The bearing materials that do not meet the required bearing capacity shall be compacted or replaced with engineered control fill.
- f. All footing excavations shall be observed by the geotechnical engineer of record or his designated representative prior to placement of reinforcing steel.

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.

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- 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 0 and +4 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 0 and +4 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.
 - 5. The upper 12 inches of material in cut area shall be low volume change material.
- 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 0 and +4 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.

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- 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 0 and +4 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 0 and +4 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. Recompect and retest until required density and moisture content is obtained.
 6. The upper 12 inches of fill material shall be low volume change material.
- D. Tolerances
 1. Top surface of finish subgrade under paved areas: Plus or minus $\frac{1}{4}$ 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 0 and +4 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.

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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 or 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 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.
- 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 0 and +4 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 0 and +4 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 0 and +4 percent above optimum moisture content in accordance with ASTM D698.

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- 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 $\frac{1}{4}$ inch from required elevations.
 - 2. Top surface of finish subgrade under unpaved surfaces: Plus or minus $\frac{1}{2}$ 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:

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1. Top surface of finish subgrade under slabs-on-grade: Plus or minus $\frac{1}{4}$ 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 $\frac{1}{4}$ 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 plate 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

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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 placed 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
- 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. 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 exceeding 6 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.
- G. Compaction of Trench Backfill

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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.
- H. 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
- I. Tolerances:
1. Top surface of finish subgrade under paved areas: Plus or minus $\frac{1}{4}$ inch from required elevations
 2. Top surface of finish subgrade under unpaved areas. Plus or minus $\frac{1}{2}$ 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.

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- 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

Contract Documents

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Clark & Enersen Project No. 624-223-23

**SECTION 31 23 19
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. "Temporary Facilities and Controls" for temporary utilities and support facilities.
 - 2. "Excavation Support and Protection."
 - 3. "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.

DEWATERING

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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

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SECTION 32 13 13 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.

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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% ($\pm 1\%$) 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 FIBER REINFORCEMENT

- A. Synthetic Fiber: Provide fibrillated polypropylene fibers engineered and designed for use in concrete paving, complying with ASTM C 1116/C 1116M, Type III, 1/2 to 1-1/2 inches long.

2.04 CURING MATERIALS

- A. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.

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2.05 RELATED MATERIALS

- A. Joint Fillers: ASTM D 1751, asphalt-saturated cellulosic fiber.

2.06 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 side-walks. 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.

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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.

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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 re-placed 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 (95°) 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.

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- 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 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.

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3.12 FIELD QUALITY CONTROL

- A. Delivery Tickets: For each load delivered, submit 3 copies indicating quantity, mix identification, admixtures, design strength, aggregate size, design air content, and design slump at time of batching.
- B. Tests: Owner will retain the services of an engineering inspection and testing firm. Contractor will be responsible for coordinating and scheduling inspection. Tests will include the following: strength, air entrainment, temperature, and slump tests. Test results will be specified to be sent directly to the Contractor, Engineer and Owner's representative.
 - 1. Testing agency shall perform sampling and testing of concrete specified in ACI 301 Sections 16.3, 16.4, and as follows:
 - a. Test data from concrete cylinder breaks will be evaluated using procedures of the American Concrete Institute (latest edition of ACI 214) to determine if the compressive strength of the concrete tested is acceptable.
 - b. Concrete will be tested at the minimum rate of one test for the first 25 cubic yards [CY] placed each day, and one test for each additional 50 CY placed. Concrete may be tested more often at the discretion of the Owner's Representative.
 - 1) One additional set of test cylinders will be taken during cold weather, and as directed by Engineer, cured at Project Site under same conditions as concrete it represents.
 - c. Slump, ASTM C143: 1 per each set of compressive cylinders.
 - d. Air content, ASTM C173: 1 per every 50 cubic yards, or portion thereof.
 - e. Unit weight, ASTM C138: 1 per every 50 cubic yards, or portion thereof.
 - f. Concrete temperature, ASTM C1064: 1 measurement for every slump test.
 - g. Casting of compressive cylinders, ASTM C39: 1 set of 4 cylinders for every 50 cubic yards, or portion thereof.
 - h. Concrete delivery: Check batch ticket from every truck.
 - 2. Batch plant inspection: Random basis as determined by Engineer.

END OF SECTION 321313

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SECTION 32 13 73 CONCRETE PAVING JOINT SEALANT

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. Section Includes:
 - 1. Cold-applied joint sealants.
- B. Related Sections:
 - 1. Division 32 Section "Concrete Paving" for constructing joints in concrete pavement.

1.03 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.

1.04 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.

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2. Interpretation of test results and written recommendations for primers and substrate preparation needed for adhesion.

1.05 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.

1.06 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.

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2.02 COLD-APPLIED JOINT SEALANTS

- A. Multicomponent, Pourable, Traffic-Grade, Urethane Joint Sealant for Concrete: ASTM C 920, Type M, Grade P, Class 25, for Use T.
 - 1. Products: Subject to compliance with requirements provide the following:
 - a. Pecora Corporation: Urexpam NR-200.
 - b. Sika Corporation: Sikaflex-2C SL and Sikaflex-2C NS TG.
 - c. BASF: Sonolastic SL2.

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.

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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.

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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 32 31 13
HIGH-SECURITY CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. High-security chain-link fences.
 - 2. Horizontal-slide, motor-operated gates.

1.02 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For each type of fence and gate assembly.
 - 1. Include plans, elevations, sections, details, and attachments to other work.
- C. Samples: For each exposed product and for each color and texture specified.
- D. Delegated-Design Submittal: For structural performance of chain-link fence and gate frameworks, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.04 INFORMATIONAL SUBMITTALS

- A. Product certificates.
- B. Product test reports.
- C. Field quality-control reports.
- D. Sample warranty.

1.05 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

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1.06 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of high-security chain-link fences and gates that fail in materials or workmanship within specified warranty period.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, to design chain-link fence and gate frameworks.
- B. Structural Performance: Chain-link fence and gate frameworks shall withstand the design wind loads and stresses for fence height(s) and under exposure conditions indicated according to ASCE/SEI 7:

2.02 CHAIN-LINK FENCE FABRIC

- A. General: Provide fabric in height measured between top and bottom of outer edge of selvage according to "CLFMI Product Manual" and requirements indicated below:
 - 1. Fabric Height: One piece widths from 36 inches to 10 feet.
 - a. Steel Wire for Fabric: Wire diameter of **0.192 inch (4.88 mm)**.
 - 1) Mesh Size: **2 inches (50 mm) 1 inch.**
 - 2. Polymer-Coated Fabric: ASTM F668, Class 2b over zinc-coated steel wire.
 - a. Color: As selected by Architect from manufacturer's full range, according to ASTM F934.
 - 3. Selvage: Twisted and barbed top and bottom.

2.03 SECURITY FENCE FRAMEWORK

- A. Posts and Rails Comply with: ASTM F1043 for framework, including rails, braces, and line; terminal; and corner posts.
 - 1. Fence Height: **96 inches (2440 mm)**.
 - 2. Metallic Coating for Steel Framework:
 - a. Type A, zinc coating.
 - b. Type B, zinc with organic overcoat.
 - c. External, Type B, zinc with organic overcoat and internal, Type D zinc-pigmented coating.
 - d. Type C, Zn-5-Al-MM alloy coating.
 - e. Coatings: Any coating above.
 - 3. Polymer coating over metallic coating.
 - a. Color: As selected by Architect from manufacturer's full range, according to ASTM F934.

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2.04 TENSION WIRE

- A. Polymer-Coated Steel Wire: **0.177-inch- (4.5-mm-)** diameter, tension wire according to ASTM F1664, Class 2b over zinc-coated steel wire.
 - 1. Color: As selected by Architect from manufacturer's full range, according to ASTM F934.

2.05 HORIZONTAL-SLIDE GATES

- A. General: ASTM F1184 for gate posts and single sliding gate types.
 - 1. Classification: Type II Cantilever Slide, Class 2 with internal roller assemblies.
- B. Pipe and Tubing:
 - 1. Gate Posts: ASTM F1184 Provide round tubular steel posts.
 - 2. Gate Frames and Bracing: Round tubular steel.
- C. Frame Corner Construction: Welded.
- D. Extended Gate Posts and Frame Members: Extend gate posts and frame end members above top of chain-link fabric at both ends of gate frame as required to attach barbed wire assemblies.

2.06 FITTINGS

- A. Provide fittings according to ASTM F626.
- B. Barbed Wire Arms: Pressed steel, with clips, slots, or other means for attaching strands of barbed wire, and means for attaching to posts, integral with post cap, for each post unless otherwise indicated, and as follows:
 - 1. Provide line posts with arms that accommodate top rail or tension wire.
 - 2. Provide corner arms at fence corner posts unless extended posts are indicated.
 - 3. Single-Arm Type: Type I, slanted arm.
- C. Power-Driven Fabric Fasteners: As recommended in writing by manufacturer.
- D. Finish:
 - 1. Metallic Coating for Pressed Steel or Cast Iron: Not less than **1.2 oz. /sq. ft. (366 g/sq. m)** of zinc.
 - a. Polymer coating over metallic coating.

2.07 BARBED WIRE

- A. Polymer-Coated, Galvanized-Steel Barbed Wire: ASTM F1665, Type II, three-strand barbed wire; **0.080-inch- (2.03-mm-)** diameter line wire with **0.080-inch- (2.03-mm-)** diameter, four-point, round galvanized-steel barbs spaced not more than **3 inches (76 mm)** o.c.
 - 1. Polymer Coating: Class 2b over zinc-coated steel wire.

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- a. Color: As selected by Architect from manufacturer's full range according to ASTM F934.

2.08 GATE OPERATORS

- A. Operators: Factory-assembled, automatic gate-operating system designed for gate size, type, weight, and frequency of use. Control system shall have characteristics suitable for Project conditions, with control stations, safety devices, and weatherproof enclosures.
 1. Operator design shall allow for removal of cover or motor without disturbing limit-switch adjustment and without affecting auxiliary emergency operation.
 2. Electronic components shall have built-in troubleshooting diagnostic feature.
 3. Unit shall be designed and wired for both right-hand/left-hand opening, permitting universal installation.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. UL Standard: Manufacture and label gate operators according to UL 325.
- D. Motors: Comply with NEMA MG 1.
 1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
 2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
 3. Service Factor: 1.15.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Do not begin installation before final grading is completed unless otherwise permitted by Architect.

3.02 PREPARATION

- A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet (152 m) or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

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3.03 CHAIN-LINK FENCE INSTALLATION

- A. Install chain-link fencing according to ASTM F567 and more stringent requirements specified.
- B. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.
- C. Post Setting: Set posts in concrete with mechanical anchors at indicated spacing into firm, undisturbed soil.
 - 1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
 - 2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
 - a. Exposed Concrete: Extend **2 inches (50 mm)** above grade or to same elevation as concrete grade beam; shape and smooth to shed water.
 - b. Concealed Concrete: Place top of concrete **2 inches (50 mm)** below grade to allow covering with surface material.
 - c. Posts Set into Sleeves in Concrete: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts are inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout or anchoring cement, mixed and placed according to anchoring material manufacturer's written instructions. Finish anchorage joint to slope away from post to drain water.
 - d. Posts Set into Holes in Concrete: Form or core drill holes not less than **5 inches (127 mm)** deep and **3/4 inch (19 mm)** larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout or anchoring cement, mixed and placed according to anchoring material manufacturer's written instructions. Finish anchorage joint to slope away from post to drain water.
- D. Terminal Posts: Install terminal end, corner, and gate posts according to ASTM F567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more, at any abrupt change in grade, and at intervals not greater than **500 feet (152 m)**. For runs exceeding **500 feet (152 m)**, space pull posts an equal distance between corner or end posts.
- E. Line Posts: Space line posts uniformly at **10 feet (3 m)** o.c.
- F. Barbed Wire Arms: Bolt or rivet to top of post. Angle single arms away from approach side of fence.
- G. Tension Wire: Install according to ASTM F567, maintaining plumb position and alignment of fence posts. Provide horizontal tension wire at the following locations:
 - 1. Extended along top and bottom of fence fabric.
- H. Bottom Rails: Secure to posts with fittings; anchor rail at midspan to concrete footing.
- I. Chain-Link Fabric: Apply fabric on the approach side of fence, inside of enclosing framework. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.

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1. Overlapping Fabric: Overlap ends of fence fabric at or between posts or rails; overlap **6 inches (152 mm)** and secure with wire ties or steel strap method.
 2. Bottom Clearance: Leave **1-1/2 inches (38 mm)** between finish grade or surface and bottom selvage unless otherwise indicated.
- J. Power-Fastening of Fabric: Fasten **0.192- or 0.148-inch (4.87- or 3.76-mm)** wire fabric with **2- or 1-inch (50- or 25-mm)** mesh size. Fasten fabric to line posts **12 inches (300 mm)** o.c. and to braces **24 inches (610 mm)** o.c.
- K. Fasteners: Install nuts for tension bands and carriage bolts on the side of fence opposite the fabric side. Peen ends of bolts or score threads to prevent removal of nuts.
- L. Barbed Wire: Install barbed wire uniformly spaced, angled toward security side of fence. Pull wire taut, install securely to extension arms, and secure to end post or terminal arms.

3.04 GATE-OPERATOR INSTALLATION

- A. Ground electric-powered motors, controls, and other devices according to NFPA 70 and manufacturer's written instructions.

3.05 ADJUSTING

- A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.
- B. Automatic Gate Operator: Energize circuits to electrical equipment and devices, start units, and verify proper motor rotation and unit operation.
1. Test and adjust operator, controls, alarms, and safety devices. Replace damaged and malfunctioning controls and equipment.
 2. Lubricate operator and related components.
- C. Lubricate hardware and other moving parts.

END OF SECTION

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**SECTION 32 91 19
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.

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- 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.

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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

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**SECTION 32 92 19
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.

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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 $\frac{1}{4}$ " to $\frac{3}{8}$ " in the soil by means of a harrow or cultipacker.

3.03 HYDROSEEDING

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- 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.

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- 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,

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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 33 31 00
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.

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- 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.

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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.

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- 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.

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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 33 41 00 STORM UTILITY DRAINAGE PIPING

PART 1 GENERAL

1.01 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.

1.02 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.

1.03 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Not less than 5 years experience in the actual production of specified products.

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- 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.

1.04 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

2.01 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.

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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.

2.02 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, cast 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. Gate: 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.

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- b. Comparable products of other manufacturers.

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, 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

3.01 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 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.

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- 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.

3.03 PROTECTION

- A. Protect installed sewage system from damage of displacement until backfilling operation is complete.

END OF SECTION

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SECTION 33 46 13 FOUNDATION DRAINAGE

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Building perimeter drainage system.
 - 2. Retaining wall drainage system.
 - 3. Under slab-on-fill drainage system.
 - 4. Related accessories.
- B. Related Sections:
 - 1. Section 312000 – Earth Moving.
 - 2. Section 334100 - Storm Utility Drainage Piping.

1.02 SUBMITTALS

- A. Submit in accordance with Division 1 unless otherwise indicated.

1.03 PRODUCT DATA

- A. Manufacturer's specifications and technical data including the following:
 - 1. Pipe drainage products and accessories.
 - 2. Filter fabric.
- B. Samples:
 - 1. Submit samples of the following:
 - 2. Filter fabric.
- C. Contract Closeout Submittals: Submit in accordance with Division 1.
- D. Project Record Documents.
 - 1. Accurately record location of underground utilities, by horizontal dimensions from above grade permanent fixtures, elevations or inverts, and slope gradients.

1.04 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:

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1. Not less than 3 years experience with systems.
2. Successfully completed not less than 5 comparable scale projects using this system.

1.05 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

2.01 MATERIALS

- A. High Density Polyethylene (HDPE) pipe and fittings: AASHTO M252, Type S; AASHTO M294, Type S. All joints shall meet the requirements of a soil-tight joint unless otherwise specified.
 1. Perforation: Class II perforation per AASHTO M252 and M294.
- B. Fittings: As required for installation of drainage system.
- C. Filter Aggregate and Bedding Materials: Granular Fill as specified under Section 312000.
- D. Drainage Panels: Prefabricated geocomposite, 36 to 60 inches (915 to 1525 mm) wide with drainage core faced with geotextile filter fabric.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Comparable product by one of the following:
 - a. [American Wick Drain.](#)
 - b. [Cosella-Dorken Products, Inc.](#)
 - c. [Eljen Corporation.](#)
 - d. [Greenstreak.](#)
 - e. [JDR Enterprises, Inc.](#)
 - f. [Midwest Diversified Technologies Incorporated.](#)
 - g. [TenCate Geosynthetics.](#)
 - h. [Trace-LINQ Inc.](#)
 3. Drainage Core: Three-dimensional, nonbiodegradable, molded PP.
 - a. Minimum Compressive Strength: 10,000 lbf/sq. ft. (479 kPa) when tested according to ASTM D 1621.
 - b. Minimum In-Plane Flow Rate: 2.8 gpm/ft. (35 L/min. per m) of unit width at hydraulic gradient of 1.0 and compressive stress of 25 psig (172 kPa) when tested according to ASTM D 4716.
 4. Filter Fabric: Nonwoven needle-punched geotextile, manufactured for subsurface drainage, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with the following properties determined according to AASHTO M 288:

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- a. Survivability: Class 1.
 - b. Apparent Opening Size: **No. 40** (0.425-mm) sieve, maximum.
 - c. Permittivity: 0.5 per second, minimum.
5. Film Backing: Polymeric film bonded to drainage core surface.

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. Preparation
1. Grade bottom of excavations 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 clean sand or pea gravel.
 3. Shape bottom of excavation to fit design of pipe.
 - a. Fill unevenness with tamped sand backfill.
 4. Remove large stones or other hard matter which could damage drainage pipe or impede consistent backfilling or compaction.

3.03 INSTALLATION

- A. Comply with manufacturer's instructions.
- B. Install pipe beginning at low point of system, true to grades and alignment indicated, with maximum variation from true slope of 1/8 inch in 10 feet.
1. Install PVC pipe in accordance with ASTM D2855 and ASTM F402.
 2. Cap upper ends of pipe.
- C. Install filter fabric over subgrade in area to receive perforated pipe.
1. Place 2 inch deep by not less than 12 inch wide bedding aggregate over filter fabric.
- D. Install pipe over bedding aggregate with perforations facing down.
1. Mechanically join pipe ends.
- E. Install drainage panel over waterproofing in accordance with manufacturer's instructions.
1. Overlay drainage panel filter fabric in the direction of water flow at panel joints.
 2. Peel back lower 15 inches of fabric and wrap fabric around drain pipe, tucking fabric securely under pipe.

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3. Coordinate installation with Division 7.
- F. Install filter aggregate at sides and top of pipe in 4 inch lifts.
 1. Do not displace or damage pipe when placing filter aggregate.
 2. Provide top cover of filter aggregate of not less than 24 inches of depth, and as indicated on Drawings.
 3. Level top of aggregate cover.
- G. Wrap filter fabric over aggregate cover prior to backfilling.
- H. Coordinate final backfilling and compaction operations with Sections 312000.
 1. Do not allow backfilling operations to commence without observation of completed system by Engineer.
 2. Do not allow drainage pipe to be displaced during backfilling and compaction operations.
- I. Connect drainage pipe to storm drainage system using unperforated pipe or through installed sleeves.

3.04 FIELD QUALITY CONTROL

- A. Provide in accordance with Division 1.
- B. Inspections: Allow Engineer to observe installed system prior to installation of filter aggregate cover.
- C. Tests: Upon completion of installation, test drainage pipe for free flow of water.

END OF SECTION