Volume 2

PROJECT MANUAL for

Wayne County Public Schools

Rosewood Middle School Addition & Renovation

541 NC 581 S
Goldsboro NC 27530

BID DOCUMENTS
January 10, 2025

DKA Project Number 2401

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Wayne County Public Schools

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Bid Documents
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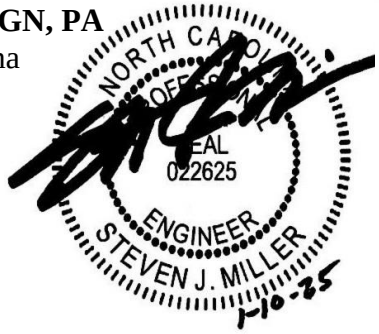

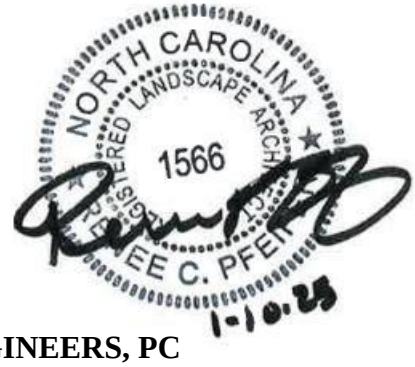

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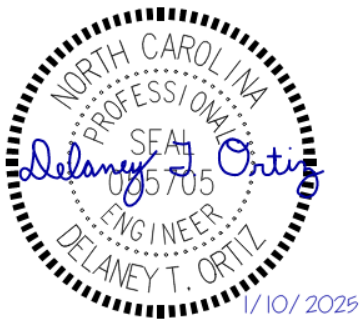

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PART 1 - GENERAL

1.1. STIPULATIONS

A. General provisions of the contract documents including general and supplementary conditions apply to all work in this division.

B. The general conditions shall be carefully examined before proposals for any work are submitted. Division twenty-one shall not be interpreted as waiving or overruling any requirements expressed in the general conditions unless division twenty-one specifications contain statements more definitive or more restrictive.

C. Nothing herein contained shall be so construed as to relieve the contractor from performing their work according to the true intent and meaning of the contract drawings and specifications. The contractor will be held responsible to provide all materials and equipment and shall provide all labor necessary for the complete, prompt, and satisfactory execution of the work. The contractor is also responsible for the proper coordination of their work with all other trades.

D. The contractor shall bear all expenses incidental to the satisfactory completion of the work contained in the contract drawings and specifications.

1.2. DEFINITIONS

A. Where words and phrases used throughout the contract documents are not specifically defined on the documents or in the reference standards, they shall be interpreted by the meanings given to them in the latest edition of the Merriam-Webster dictionary.

B. Words and phrases used throughout the contract documents shall be interpreted as indicated below:
   1. Concealed, exterior installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures.
   2. Concealed, interior installations: Concealed from view and protected from physical contact by building occupants.
   3. Contractor: The person or organization awarded the contract for construction services. In the case of a construction project administered as a multiple-prime contract, the term shall be further defined as the contractor holding a prime contract for fire protection construction work.
   4. Exposed, exterior installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions.
   5. Exposed, interior installations: Exposed to view indoors.
   6. Finished spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, tunnels, or similar spaces where building occupants do not regularly spend time.
   7. Furnish items to owner or others: Contractor shall select, purchase, and deliver materials, equipment, or systems for installation by the owner or others.
   8. Install items furnished by owner or others: The contractor shall receive shipment, store, install, and verify materials, equipment, or systems selected and purchased outside of their construction contract.
   9. Occupancy, further defined as follows:
      a. Full owner occupancy: Owner will occupy the areas of work during the entire construction period.
      b. Partial owner occupancy: Owner may occupy completed areas of work before owner acceptance.
   10. Others: A person or organization other than the contractor, owner, or professional.
   11. Owner: The person or organization that awards the construction contract, or their designated representative.

12. Owner acceptance or substantial completion: Work that is judged by the professional to be substantially complete, accepted to be safe for use by the authority having jurisdiction, and accepted by the Owner. Acceptance comes with an agreement that the professional's written punchlist of outstanding items will be completed to fulfill the contractual obligations.
13. Professional: The engineer of record.
14. Provide: To furnish and install materials, equipment, or systems.
15. Submittals: Industry standards, manufacturer's data, manufacturer's warranties, operation and maintenance instructions, shop drawings, and test reports.
16. Work: All labor, materials, equipment, and services necessary and reasonably incidental to the proper completion and proper operation of the fire protection systems.

1.3. REFERENCES

A. The contractor shall comply with all laws, ordinances, and regulations of all authorities having jurisdiction, including those of all applicable city, county, state, federal, and public utility entities.

B. The publications listed below form a part of this specification. All publications shall be the latest edition as adopted by the authority having jurisdiction at the date of bid advertisement. The minimum standard of work under this contract shall be in accordance with the following model building codes or standards:
1. ASTM International:
   a. ASTM A53 – Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   b. ASTM C1107 – Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).
2. International Building Code (IBC) with North Carolina Amendments:
   a. North Carolina Building Code.
   b. North Carolina Fire Prevention Code.
   c. North Carolina Mechanical Code.
3. National Fire Protection Association:
   a. NFPA 13 – Standard for the Installation of Sprinkler Systems.
   b. NFPA 25 – Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.
   c. NFPA 70 – National Electric Code.
   d. NFPA 72 – National Fire Alarm and Signaling Code.

1.4. RELATED WORK

A. The contractor shall obtain all licenses, permits, etc. and shall pay all associated connection fees, tapping fees, inspection fees, etc. These costs shall be included in the contract price.

B. All work related to providing complete fire protection systems and equipment shall be the responsibility of the contractor. The following related work shall be provided as indicated in other specification divisions:
1. Fire alarm contractor:
   a. Wiring connections of all pipeline installed devices to the building fire alarm system provided by the contractor.
   b. Installation of all supervisory signal devices for pipeline installed accessories and wiring connections of these devices to the building fire alarm system.
   c. Programming logic for all contractor provided fire alarm and signaling devices.
2. General contractor:
   a. Installation of access panels.
   b. Cutting and patching: The general contractor shall perform cutting and patching of floor slabs-on-grade, exterior walls, and roofs when necessary for the installation of the work. All costs associated for this work shall be paid by the contractor.
   c. Painting: The general contractor shall perform all required painting of piping provided by the contractor.

1.5. QUALITY ASSURANCE

A. The contractor shall become thoroughly familiarized with all specifications and drawings for the project so that they clearly understand their responsibility in relationship to the work to be performed. The contractor shall plan and perform their work to permit the use of the building at the earliest possible date.

B. Changes from the contract documents necessary to coordinate the work with other trades, to conform to the building conditions, or to conform to the rules and regulations of authorities having jurisdiction shall be made only after obtaining written permission from the professional.

C. The contractor is responsible for the proper installation of all materials and equipment required for a complete installation within the intent and meaning of the contract documents.

D. The contractor shall expressly and completely follow manufacturer's instructions required for validation of the manufacturer's warranty agreement including but not limited to service, maintenance, and adjustments of the equipment.

E. The contractor shall guarantee all work, materials, and equipment furnished against defects, leaks, performance, and non-operation for a period of one (1) year after the date of the owner's acceptance, or as indicated in the general conditions. Defects shall be interpreted as defective materials or equipment or unsatisfactory installation and are not intended to apply to ordinary wear and tear. The contractor shall pay for any repairs or replacements caused by these defects within the period covered by the guarantee, including all incidental work required to fix the deficiency.

1.6. MATERIALS

A. Any device that has the physical appearance of life safety or fire protection equipment but does not perform that life safety or fire protection function shall be prohibited.

B. Provide products requiring electrical connections listed and labeled by Underwriters Laboratories, Inc. (UL), as suitable for the purpose specified and indicated.

1.7. FIELD MEASUREMENTS

A. Before ordering any equipment and material, or performing any work, the contractor shall verify all measurements and dimensions in the areas of work. The contractor is responsible for the correctness of this information.

B. Any difference identified by the contractor shall be submitted to the professional for consideration before proceeding with the work.

C. No extra compensation will be considered based on differences between actual dimensions and measurements and those indicated on the drawings.

1.8. PROTECTION OF UTILITIES

A. All existing service utilities shall remain active during construction. Any service underground, aboveground, interior, or exterior damaged, broken, or otherwise rendered inoperative during the completion of the work due to activities on the part of the contractor shall be properly repaired by the contractor at their own expense. The method used in repairing, replacing, or maintaining the services shall be submitted to the professional for review and approval.

1.9. INTERRUPTION OF UTILITIES

A. The contractor shall schedule their work to avoid interruption of any utility services.

B. Existing utilities serving occupied facilities shall not be interrupted except when such interruptions have been authorized by the owner. Interruptions may occur only after acceptable temporary utility services have been provided. The contractor shall provide a minimum of seventy-two (72) hours' notice to the owner and receive written notice to proceed before interrupting any utility.

1.10. IMPAIRMENT OF FIRE PROTECTION SYSTEMS

A. Where a required fire protection system is out of service, the fire department shall be notified immediately and, where required by the fire code official, the building shall either be evacuated or an approved fire watch shall be provided for all occupants left unprotected by the shutdown until the fire protection system has been returned to service.

B. Where utilized, fire watch personnel shall each be provided with at least one approved means for notification of the fire department and their only duty shall be to perform constant patrols of the protected premises and keep watch for fires.
   1. Approved means of direct communication may include cellular phones, landline phones, handheld transceivers, or any other form of instant audio communication at the discretion of the professional. Email communications, text messaging, or any other form of text-based or visual communication are prohibited.

C. The building owner shall assign an impairment coordinator to comply with the requirements of this section. In the absence of a specific designee, the owner shall be considered the impairment coordinator.

D. A tag shall be used to indicate that a system, or portion thereof, has been removed from service.

E. The tag shall be posted at each fire department connection, system control valve, fire alarm control unit, fire alarm annunciator, and fire command center, indicating which system, or part thereof, has been removed from service. The fire code official shall specify where the tag is to be placed.

F. Preplanned impairments shall be authorized by the impairment coordinator. Before authorization is given, a designated individual shall be responsible for verifying that all the following procedures have been implemented:
   1. The extent and expected duration of the impairment have been determined.
   2. The areas or buildings involved have been inspected and the increased risks determined.
   3. Recommendations have been submitted to management or building owner/manager.
   4. The fire department has been notified.
   5. The insurance carrier, the alarm company, building owner/manager, and other authorities having jurisdiction have been notified.
   6. The supervisors in the areas to be affected have been notified.
   7. A tag impairment system has been implemented.
   8. Necessary tools and materials have been assembled on the impairment site.

G. When unplanned impairments occur, appropriate emergency action shall be taken to minimize potential injury and damage. The impairment coordinator shall implement the steps outlined for preplanned impairments.

H. When impaired equipment is restored to normal working order, the impairment coordinator shall verify that all the following procedures have been implemented:
   1. Necessary inspections and tests have been conducted to verify that affected systems are operational.
   2. Supervisors have been advised that protection is restored.
   3. The fire department has been advised that protection is restored.
   4. The building owner/manager, insurance carrier, alarm company, and other involved parties have been advised that protection is restored.
   5. The impairment tag has been removed.

1.11. PROTECTION OF WORK

A. At their own expense, the contractor shall protect their work, materials, and equipment that is subject to damage during the project duration. All openings into any piping or equipment shall be securely covered, or otherwise protected, to prevent injury due to carelessly or maliciously dropped tools or materials, grit, dirt, or any foreign material. The contractor is responsible for all damage until their work is fully and finally accepted.

1.12. CHASES AND OPENINGS

A. All chases and openings required for the installation of the work shall be coordinated with the work of other trades. The contractor shall provide the other trades with sufficient time for coordination of all chases and openings. The contractor shall be responsible for cutting and patching all openings in walls and partitions necessary for the work.

B. The contractor shall provide all sleeves, hangers, and anchors required for installation of the work in chases and openings.

1.13. MISCELLANEOUS STEEL AND ACCESSORIES

A. The contractor shall provide all necessary steel angles, channels, pipe, rods, nuts, bolts, etc. as shown on plans, as specified, or as may be required for complete and proper installation of the work. All material and workmanship shall be of the best quality and shall be installed in accordance with the best practices of the trade.

1.14. CROSS CONNECTION CONTROL

A. The contractor shall coordinate water service requirements in accordance with the local water utility regulations, including required permits, backflow preventers, meters, piping, valves, bypasses, supports, and other accessories.

B. Where these services are provided by others, the contractor shall verify that they are complete and have been inspected prior to making final connection(s).

1.15. CLEANUP

A. The contractor shall provide containers for collection of waste materials, debris, and rubbish. Waste materials, debris, and rubbish shall be removed from the job site and legally disposed of at a landfill area in accordance with all applicable regulations. Burning or burying waste materials, debris, or rubbish on project site is not permitted.

B. The contractor shall maintain buildings, grounds, and public properties free from accumulations of waste materials, debris, and rubbish. At reasonable intervals during the progress of work, and when directed by the owner, the site and public properties shall be cleaned and waste materials, debris, and rubbish disposed of in an appropriate manner.

C. At the completion of the project, the contractor shall remove waste materials, rubbish, tools, equipment, machinery, surplus materials, etc., and clean all sight-exposed accessories and equipment; remove grease, dust, dirt, stains, labels, fingerprints, and other foreign materials from sight-exposed accessories and equipment; broom clean paved and concrete surfaces; rake clean other ground surfaces; repair, patch, and touch-up marred surfaces to the specified finish or to match adjacent surfaces.

1.16. PROJECT CLOSEOUT DOCUMENTATION

A. Changes from the contract documents necessary to coordinate the work with other trades, to conform to the building conditions, or to conform to the rules and regulations of authorities having jurisdiction shall be made only after obtaining written permission from the professional.

B. The contractor shall keep a record of construction changes and deviations from the original contract documents. All changes shall be recorded on a separate set of prints, which shall be kept at the project site specifically for that purpose. The record shall be made immediately after the work is completed. Documentation shall include:
   1. Location and elevation of new utility lines.
   2. Changes in pipe size and routing location.
   3. Valve locations.
   4. Equipment locations.
   5. Actual capacities and values of equipment provided.

C. The marked-up record set of construction documents shall be delivered to the professional after final acceptance of the work.

D. The contractor shall deliver operation and maintenance manuals per section 22 01 05 to the professional before instruction of the owner and after final acceptance of the work.

1.17. INSTRUCTION OF THE OWNER

A. After acceptance of the project, the contractor shall furnish the services of personnel thoroughly familiar with the completed installation to instruct the owner in the proper operation and maintenance of all equipment and appurtenances provided.

B. The contractor shall provide the owner with ten (10) business days' notice before the instruction session(s).

PART 2 - PRODUCTS

2.1. ACCESS PANELS

A. Access panels shall be of sufficient size to permit access, except that the minimum size shall be twelve (12) inches by sixteen (16) inches.

B. Access doors shall be suitable for installation in the finish material of the ceiling, wall, partition, or floor in which they are installed.

C. Access doors with an Underwriter's Laboratory listing shall be provided in fire-resistance-rated construction assemblies. Access doors shall have a fire-resistance rating of no less than that required by the listing of the assembly in which they are installed. Maximum size shall be twenty (20) inches by twenty (20) inches or four hundred (400) square inches in area. Frame shall be sixteen (16) gauge minimum steel, panel shall be twenty (20) gauge minimum steel.

D. Access doors without an Underwriter's Laboratory label shall be provided in all non-rated construction assemblies. Frame shall be sixteen (16) gauge minimum steel, panel shall be fourteen (14) gauge minimum steel.

E. Frames and panels for access doors in restrooms, kitchens, and as indicated shall be stainless steel.

F. Access doors shall be provided with a baked-on enamel finish (prime coat), concealed spring type hinges, flush-face type lock with key operation, and self-latching cylinder locks.

G. Access doors shall open a minimum of one-hundred-seventy-five (175) degrees.

H. All access doors shall be keyed alike. Coordinate locking mechanism type with owner prior to purchase and installation.

2.2. SLEEVES

A. Cast iron wall pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized steel wall pipes: ASTM A53, schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized steel pipe sleeves: ASTM A53, type E, grade B, schedule 40, zinc coated, with plain ends.

D. Galvanized steel sheet sleeves: Minimum 20-gauge thickness; round tube closed with welded longitudinal joint.

E. Polyvinyl chloride (PVC) pipe sleeves are not acceptable.

2.3. SLEEVE SEAL SYSTEMS

A. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
1. Sealing elements: Ethylene propylene diene monomer (EPDM) rubber or nitrile butadiene rubber (NBR) interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure plates: Stainless steel.
3. Connecting bolts and nuts: Stainless steel of length required to secure pressure plates to sealing elements.

B. Polyvinyl chloride (PVC) sleeve seal systems are not acceptable.

2.4. GROUT

A. Standard: ASTM C1107, grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink; recommended for interior and exterior applications.

C. Design mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1. GENERAL

A. The contract documents are diagrammatic and are indicative of the work to be performed. It is not intended that they show every pipe, fitting, offset, change in direction, or appurtenance required for a complete installation.

B. All materials and equipment used shall be installed in strict accordance with the standards under which the materials are accepted and approved, and in strict accordance with the manufacturer’s printed instructions.

3.2. ACCESS PANEL INSTALLATION

A. The contractor shall furnish access doors to the general contractor for installation in ceilings, walls, partitions, and floors for access to valves, drains, and other appurtenances which require routine access for proper maintenance, operation, and inspection.

B. Access door locations shall be as determined by field conditions for optimum access to equipment and shall be reviewed by the owner and professional before final installation. Access door locations shall be subject to the following:
   1. Bottom of access doors shall not be lower than the top of the partition base, or a minimum of six (6) inches above floor, whichever is greater.
   2. Tops and/or sides of access panels shall be a minimum of six (6) inches from the ceiling, any other opening, or from the edge of a wall.

3.3. SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
   1. Galvanized steel pipe sleeves: Interior fire-rated partitions; interior non-rated partitions; and concrete slabs above grade.
   2. Galvanized steel sheet sleeves: Interior non-rated partitions.
   3. Sleeves are not required for core-drilled holes.

B. Install sleeves in suspended concrete floors, concrete roof slabs, and masonry walls as new slabs and walls are constructed.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas two (2) inches above finished floor level.
   2. Using grout, seal the space outside of sleeves in slabs and walls.

C. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements of sealants.

D. Fire-resistance rated penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping per the associated UL detail's listing.

3.4. SLEEVE SEAL SYSTEM INSTALLATION

A. Cast iron pipe sleeves with sleeve seals: Exterior masonry walls above and below grade and concrete slabs on grade.

B. Select sleeve size to allow for one- (1) inch annular clear space between piping and sleeve for installing sleeve-seal system.

C. Install sleeve-seal systems in sleeves in exterior masonry walls and slabs-on-grade at service piping entries into building.

D. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.5. INSPECTION AND TESTING

A. Fire detection and alarm systems, fire-extinguishing systems, fire hydrant systems, fire standpipe systems, fire pump systems, private fire service mains and all other fire protection systems and appurtenances thereto shall be subject to acceptance tests as contained in the installation standards and as approved by the fire code official.

B. It is unlawful to occupy any portion of a building or structure until the required fire detection, alarm, and suppression systems have been tested and approved.

C. The fire code official shall be notified before any required acceptance testing.

D. The contractor shall notify the professional a minimum of five (5) business days prior to testing to coordinate the testing and inspection procedures.

E. The contractor shall provide all equipment, material, labor, etc. required for testing the fire protection systems.

F. All new, altered, extended, or replaced fire protection systems shall be left uncovered and unconcealed until they have been inspected, tested, and accepted by the professional and fire code official. Where such work has been covered or concealed before it has been inspected, tested, and accepted, it shall be uncovered by the contractor at their own expense as directed by the professional and/or fire code official.

G. If the professional or fire code official determines that the fire suppression systems do not pass the prescribed tests, then the contractor shall be required to make the necessary repairs, at their own expense, and the contractor shall re-inspect and re-test the systems. Repairing, inspection, and testing shall be continued until all systems pass as determined by the professional and fire code official.

H. The contractor shall have all associated NFPA inspection forms prepared and on site at the time of inspection for review and acceptance by the professional and fire code official. No other forms will be accepted. All non-signature form information shall be typed.

I. The contractor shall maintain a readily available copy of all inspection forms on site and shall forward a copy of each form to the owner, professional, and fire code official after testing has been completed.

END OF SECTION 210100

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SECTION 210105 - FIRE PROTECTION SUBMITTAL REQUIREMENTS

PART 1 - GENERAL

1.1. STIPULATIONS

A. General provisions of the contract documents including general and supplementary conditions apply to all work in this division.

B. Failure of the contractor to provide a complete submittal package may result in delay in processing time. All such delays to the project resulting from the contractor's failure to provide submittals in a timely fashion will be the responsibility of the contractor.

1.2. DEFINITIONS

A. Industry standard: Printed copies of the current standards recognized in the industry. Current means the latest issue as of the date of these specifications; within the text of these specifications the date suffix frequently shown with identification numbers has been omitted.

B. Manufacturer's data: Product manufacturer's standard printed information, including promotional brochures, product specifications, installation instructions and diagrams, statements of compliance with standard performance charts or curves, and similar information concerning the standard portions of a manufacturer's products.

C. Manufacturer's warranty: Manufacturer's standard printed commitment about a specific product and normal application, stating that certain acts of restitution will be performed for the purchaser or owner by the manufacturer, if and when the product fails within certain operational conditions and time limits.

D. Operation and maintenance instructions: The written instructions by the manufacturer, fabricator, or installer of equipment or systems, detailing the procedures to be followed by the owner in operation, maintenance, control, and shutdown of each operating item of the equipment or system.

E. Shop drawings: Project shop drawings and other data prepared specifically for fulfillment of the project requirements. Shop drawings include fabrication, layout, setting, installation, coordination, and similar drawings and diagrams, and include performance data associate therewith, including weights, capacities, speeds, outputs, consumption, efficiencies, voltages, amperages, cycles, phases, noise levels, operating ranges, and similar information.

F. Test reports: Specific reports prepared by an independent testing laboratory, showing the results of specified testing on either the material or equipment provided or on identical material or equipment.

1.3. SUBSTITUTIONS

A. Submittals are not opportunities for gaining acceptance of substitutions. Where three (3) or more manufacturers are specified by name or by catalog reference, the contractor shall select for use any of those so specified.

B. Should the contractor desire to substitute another manufacturer's equipment for one specified by name, the contractor shall apply in writing at least ten (10) business days prior to bid date for such permission. The contractor shall provide submittal data for the professional's consideration. No substitution shall be made for any material, article, or process under the contract unless approved by the professional.

C. Any time that is required by the professional for a request to review submittals for substitutions after the award of bids will be billed to the contractor at the professional's published hourly billing rate. The

professional's review time will be billed to the contractor whether the proposed substitution is accepted or rejected.

1.4. SUBMITTAL FORM AND PROCEDURES

A. Submittals shall be assembled as single file electronic submittals. Transmittals shall be included within the file as the first page.

B. Submittals shall be made in separate packages containing all the required documentation indicated in each specification section. Only one (1) submittal package shall be made for each specification section. Partial submissions will not be addressed.

C. Submittals shall be complete and clearly identified and cross-referenced to the appropriate specification section.

D. The data shown on the submittals shall be complete with respect to dimensions, design criteria, materials of construction, and the like to enable the professional to review the information as required.

E. The contractor shall stamp the submittals and verify by signature that the submittals have been checked for compliance with the contract documents and appropriate means have been taken to ensure that the material or equipment will fit into the space available.

F. At the time of each submission, the contractor shall in writing call the professional's attention to any deviations that the submittal may have from the requirements of the contract documents.

G. The submittals shall be clearly marked indicating which specific options are being considered and with all related information.

H. The professional's review of submittals is for general conformance with design concept only. Corrections or comments made on the submittals during review do not relieve the contractor from compliance with requirements of the contract documents.

I. The contractor is responsible for all quantities, dimensions, and coordination of the work of all trades. The contractor is responsible for selecting fabrication processes and techniques of construction and for performing all work in a safe and satisfactory manner.

J. No work requiring a submittal shall be commenced until the submittal has been reviewed by the professional.

K. A copy of each approved submittal shall be kept in good order by the contractor and shall be made available at the site.

1.5. OPERATION AND MAINTENANCE MANUALS

A. Submit after owner acceptance for review by the professional.

B. The contents of the submittal shall be prepared as follows:
   1. Table of contents.
   2. A directory listing names, addresses, and telephone number of professional, contractor, subcontractors, and equipment suppliers.
   3. Project documents and certificates:
      a. Certificates of compliance.
      b. Photocopies of warranties and bonds.
      c. Material safety data sheets (MSDS).
   4. Operation and maintenance instructions subdivided by specification section. For each item, identify the following:

a. Significant design criteria.
b. Parts list for each component.
c. Maintenance instructions for equipment and systems.
d. Maintenance instructions for finishes including recommended cleaning methods and materials and operating instructions.
e. Special precautions identifying detrimental agents.
f. Special requirements of other sections of this specification noted to be included in the operation and maintenance manual.

C. Submit copies for review by the owner ten (10) business days prior to owner training.

END OF SECTION 210105

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SECTION 210500 - FIRE PROTECTION FIRESTOPPING

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes firestopping requirements and information for Division 21 work.

1.2 DEFINITIONS

A. Firestopping: The use of a material or combination of materials in a fire-rated structure (wall or floor) where it has been breached, to restore the integrity of the fire rating on that wall or floor.

B. System: The use of a specific firestop material or combination of materials in conjunction with a specific wall or floor construction type and a specific penetrant(s).

C. Barrier: Any bearing or non-bearing wall or floor that has an hourly fire and/or smoke rating.

D. Through-Penetration: Any penetration of a fire-rated wall or floor that completely breaches the barrier.

E. Membrane-Penetration: Any penetration in a fire-rated wall or floor/roof-ceiling assembly that breaches only one side of the barrier.

F. Approved Testing Agencies: Not limited to: Underwriters Laboratory (UL), Factory Mutual (FM), Warnock Hersey, and Omega Point Laboratory (OPL).

1.3 PERFORMANCE REQUIREMENTS

A. Penetrations: Provide through-penetration and membrane-penetration firestop systems that are produced and installed to resist the spread of fire, passage of smoke and other hot gases according to requirements indicated, to restore the original fire-resistance rating of assembly penetrated.

B. Provide and install complete penetration firestopping systems that have been tested and approved by nationally accepted testing agencies per ASTM E814 or UL 1479 fire tests in a configuration that is representative of field conditions.
   1. F-Rated Systems: Provide firestop systems with F-ratings indicated and as required by the Building Code.
   2. T-Rated Systems: Provide firestop systems with T-ratings and F-ratings indicated and as required by the Building Code.
   3. L- Rated Systems: Provide firestop systems with L- ratings less than 5cfm/sf.
   4. W-Rated systems: Provide firestop systems that are resistant to water. For piping penetrations for wet-pipe sprinkler systems, provide moisture-resistant through-penetration firestop systems.

C. Firestopping products shall have flame spread ratings less than 25 and smoke-developed ratings less than 450, as determined per ASTM E 84, except firestop products installed in plenum spaces shall have a smoke developed rating less than 50.

D. Engineering Judgment (EJ): Where there is no specific third party tested and classified firestop system available for an installed condition, the Contractor shall obtain from the firestopping material manufacturer an Engineering Judgment (EJ) to be submitted to the Authority Having Jurisdiction (AHJ) and Engineer for approval. The EJ shall follow International Firestop Council (IFC) guidelines.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of firestopping product selected. Manufacturers certification must verify that firestopping materials are free of asbestos, lead and contain volatile organic compounds (VOCs) within limits of the local jurisdiction. Include the following information:
   1. Design Listings: Submit system design listings, including illustrations, from a qualified testing and inspecting agency that is applicable to each firestop configuration.
   2. Installation Instructions: Submit the manufacturer's installation instruction for each firestop assembly.
   3. Engineering Judgements: Where there is no specific third party tested and classified firestop system available for a particular configuration, the Contractor shall obtain from the firestopping material manufacturer an Engineering Judgment (EJ) for submittal.
   4. Firestop Schedule: Submit schedule itemizing the following:
      a. Manufacturer's product reference numbers and/or drawing numbers.
      b. Listing agency's design number.
      c. Penetrating Item Description/Limits: Material, size, insulated or uninsulated, and combustibility.
      d. Maximum allowable annular space or maximum size opening.
      e. Construction type.
      f. F rating and, if applicable, T, L, and W ratings.

1.5 QUALITY ASSURANCE

A. Provide firestopping system design listings from UL, FM, Warnock Hersey, or OPL in accordance with the appropriate ASTM Standard(s).

B. Single Source Limitations: Obtain firestop systems for all conditions from a single manufacturer.

C. Materials from different firestop manufacturers shall not be installed in the same firestop system or opening.

D. Firestopping material shall be asbestos and lead free and shall not incorporate nor require the use of hazardous solvents.

E. Firestopping sealants must be flexible, allowing for normal movement.

F. Firestopping materials shall not shrink upon drying as evidenced by cracking or pulling back from contact surfaces such that a void is created.

G. Firestopping materials shall be moisture resistant and may not dissolve in water after curing.

H. Materials used shall be in accordance with the manufacturer's written installation instructions.

I. All firestop materials shall be installed prior to expiration date. Store and handle materials per manufacturer's instructions to prevent deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

1.6 COORDINATION

A. Coordinate areas prior to firestopping installation with the Owner, Construction Manager, and/or all other Contractors.

B. Coordinate construction of openings and penetrating items to ensure that firestopping assemblies are installed according to specified requirements. Opening shall not exceed maximum restrictions allowable for annular spacing per listing or acceptable Engineering Judgments.

C. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.

D. Do not conceal firestopping installations until the Owner's inspection agency or Authorities Having Jurisdiction have examined each installation.

E. Schedule firestopping after installation of penetrants and joints but prior to concealing or obstructing access to areas requiring firestopping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Emerson / Nelson Firestop Products.
2. Hilti.
3. 3M, Fire Protection Products Division.
4. Tremco.

2.2 FIRESTOPPING

A. Firestopping products specified in system design listings by approved testing agencies may be used providing they conform to the construction type, penetrant type, annular space requirements and fire rating involved in each separate assembly.

B. Accessories: Provide components for each firestop system that is needed to install fill materials and to comply with "Performance Requirements" Article. Use only components specified by the firestopping manufacturer and by the approved testing agencies for the firestop systems indicated. Accessories include, but are not limited to the following items:
1. Permanent forming/damming/backing materials, including the following:
    a. Slag wool fiber insulation.
    b. Foams or sealants used to prevent leakage of fill materials in liquid state.
    c. Fire-rated form board.
    d. Polyethylene/polyurethane backer rod.
    e. Rigid polystyrene board.
2. Temporary forming materials.
3. Substrate primers.
4. Steel sleeves.

C. All firestopping products and systems shall be designed and installed so that the basic sealing system will allow the full restoration of the thermal and fire resistance properties of the barrier being penetrated with minimal repair if penetrants are subsequently removed.

D. Mold Resistance: Provide penetration firestoppping with mold and mildew resistance rating of 0 as determined by ASTM G21.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. Provide firestop systems consisting of a material, or combination of materials installed to retain the integrity of fire resistance rated construction by maintaining an effective barrier against the spread of flame, smoke and/or hot gases through penetrations, fire resistive joints, and perimeter openings in accordance with the requirements of the building code for this project.

B. Firestop systems shall be used in locations including, but not limited to, the following:
   1. Penetrations through fire resistance rated floor and roof assemblies including both empty openings and openings containing penetrants.
   2. Penetrations through fire resistance rated wall assemblies including both empty openings and openings containing penetrants.
   3. Membrane penetrations in fire resistance rated wall assemblies where items penetrate one side of the barrier.

3.2 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance.

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

C. Verify that all pipes, conduits, cables, and/or other items which penetrate fire-rated construction have been permanently installed prior to installation of firestops.

3.3 PREPARATION

A. Surface Cleaning: Clean out openings immediately before installing firestop systems to comply with written recommendations of firestopping manufacturer and the following requirements:

B. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of firestop systems.

C. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with firestop systems. Remove loose particles remaining from cleaning operation.

D. For those products requiring mixing before application, comply with firestopping manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

3.4 INSTALLATION

A. Install firestop systems to comply with firestopping manufacturer's written installation instructions and published drawings for products and applications indicated.

B. Apply firestopping in accordance with approved testing agencies listed system designs or manufacturer's EJ per the manufacturer's installation instructions.

C. Verify that environmental conditions are safe and suitable for installation of firestop products. Application areas shall be protected from weather, dry, and within recommended temperature and humidity ranges of materials being installed.

D. Install forming/damming/backing materials and other accessories required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire resistance ratings required.

E. Install metal framing, mechanical attachments, safing materials, and firestop materials as applicable within the system design.

F. Install fill materials for firestop systems by proven techniques to produce the following results:
   1. Fill voids, joints and cavities formed by openings, forming materials, accessories, and penetrating items as required to achieve fire-resistance ratings indicated.

2. Apply materials so they fully contact and adhere to substrates formed by openings and penetrating items.
3. For fill materials that will remain exposed after completing work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.
4. Tool non-sag firestop materials after their application and prior to the time skinning begins. Use tooling agents approved by the firestopping manufacturer.

G. On vertical pipe penetrations, lift riser clamps to permit the installation of firestopping around the entire pipe penetration.

3.5 FIELD QUALITY CONTROL

A. Inspecting Agency: Authorities Having Jurisdiction, the Owner, or Owner's Representative shall be allowed to perform random destructive testing during inspection of firestop systems to verify compliance per listings or manufacturer's installation instructions. All areas of work must be accessible until inspection by the applicable Authorities Having Jurisdiction and inspection agencies. The contractor shall be responsible to repair all tested assemblies with no cost to the owner.

B. Proceed with enclosing firestop systems with other construction only after inspections are complete.

C. Where deficiencies are found as determined by the Engineer remove and replace firestop systems, so they comply with requirements.

3.6 CLEANING AND PROTECTION

A. Clean off excess fill materials adjacent to openings, as work progresses by methods and with cleaning materials that are approved in writing by firestopping manufacturer(s) and that do not damage materials in which openings occur. Leave finished work in neat, clean condition with no evidence of spillovers or damage to adjacent surfaces.

B. Provide final protection and maintain conditions during and after installation that ensure firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated firestop systems immediately and install new materials to produce firestop systems complying with specified requirements.

END OF SECTION 210500

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SECTION 210523 - GENERAL-DUTY VALVES FOR FIRE PROTECTION SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Two-piece ball valves with indicators.
2. Bronze butterfly valves with indicators.
3. Iron butterfly valves with indicators.
4. Check valves.
5. Bronze OS&Y gate valves.
6. Iron OS&Y gate valves.
7. NRS gate valves.
8. Indicator posts.
9. Trim and drain valves.

B. Related Requirements:
1. Section 211119 "Fire-Department Connections" for exposed wall-mounted and yard fire hydrants.
2. Section 211313 “Wet-Pipe Sprinkler Systems” for wet-pipe sprinkler piping.
3. Section 210500 “Fire Protection Firestopping”
4. Section 283111 "Digital, Addressable Fire-Alarm System" for connections to alarm devices.

1.3 DEFINITIONS

A. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

B. NRS: Non-rising stem.

C. OS&Y: Outside screw and yoke.

D. SBR: Styrene-butadiene rubber.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, and weld ends.
3. Set valves open to minimize exposure of functional surfaces.

B. Use the following precautions during storage:
1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

D. Protect flanges and specialties from moisture and dirt.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. UL Listed: Valves shall be listed in UL's "Online Certifications Directory" under the headings listed below and shall bear UL mark:

B. Source Limitations for Valves: Obtain valves for each valve type from single manufacturer.

C. ASME Compliance:
1. ASME B16.1 for flanges on iron valves.
2. ASME B1.20.1 for threads for threaded-end valves.
3. ASME B31.9 for building services piping valves.

D. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

E. NFPA Compliance: Comply with NFPA 24 for valves.

F. Valve Pressure Ratings: Not less than the minimum pressure rating indicated or higher as required by system pressures.

G. Valve Sizes: Same as upstream piping unless otherwise indicated.

H. Valve Actuator Types:
1. Worm-gear actuator with handwheel for quarter-turn valves, except for trim and drain valves.
2. Handwheel: For other than quarter-turn trim and drain valves.
3. Handlever: For quarter-turn trim and drain valves NPS 2 and smaller.

2.2 TWO-PIECE BALL VALVES WITH INDICATORS

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:
a. Anvil International, Inc.
b. Victaulic Company.
c. United Brass Works.

A. Description:
1. UL 1091, except with ball instead of disc and FM Global standard for indicating valves (butterfly or ball type), Class Number 1112.
2. Minimum Pressure Rating: 175 psig.
3. Body Design: Two piece.
4. Body Material: Forged brass or bronze.
5. Port Size: Full or standard.
6. Seats: PTFE.
7. Stem: Bronze or stainless steel.
8. Ball: Chrome-plated brass.
9. Actuator: Worm gear or traveling nut.
10. Supervisory Switch: Internal or external.
11. End Connections for Valves NPS 1 through NPS 2: Threaded ends.
12. End Connections for Valves NPS 2-1/2: Grooved ends.

2.3 BRONZE BUTTERFLY VALVES WITH INDICATORS

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:
a. Victaulic.
b. Global Safety Products, Inc.

c. Milwaukee Valve Company.

A. Description:
1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 1112.
2. Minimum: Pressure rating: 175 psig.
3. Body Material: Bronze.
4. Seat Material: EPDM.
5. Stem Material: Bronze or stainless steel.
6. Disc: Bronze.
7. Actuator: Worm gear or traveling nut.
8. Supervisory Switch: Internal or external.
9. Ends Connections for Valves NPS 1 through NPS 1-1/2: Threaded ends.
10. Ends Connections for Valves NPS 2: Grooved ends.

2.4 IRON BUTTERFLY VALVES WITH INDICATORS
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:
a. Anvil International, Inc.
b. Kennedy Valve; a division of McWane, Inc.
c. Milwaukee Valve Company.
d. NIBCO INC.
e. Pratt, Henry Company.
f. Shurjoint Piping Products.
g. Tyco Fire & Building Products LP.
h. Reliable Automatic Sprinkler Co., Inc.

B. Description:
1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 112.
2. Minimum Pressure Rating: 175 psig.
3. Body Material: Cast or ductile iron with nylon, EPDM, epoxy, or polyamide coating.
4. Seat Material: EPDM.
5. Stem: Stainless steel.
6. Disc: Ductile iron
7. Actuator: Worm gear or traveling nut.
8. Supervisory Switch: Internal or external.
9. Body Design: Lug, wafer, or grooved-end connections.

2.5 CHECK VALVES
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:
a. Anvil International, Inc.
b. Clow Valve Company; a division of McWane, Inc.
c. Crane Co.; Crane Valve Group; Crane Valves.
d. Globe Fire Sprinkler Corporation.
e. Kennedy Valve; a division of McWane, Inc.
f. Milwaukee Valve Company.
g. Mueller Co.; Water Products Division.
h. NIBCO INC.
i. Reliable Automatic Sprinkler Co., Inc.
j. Shurjoint Piping Products.
k. Tyco Fire & Building Products LP.
l. Victaulic Company.
m. Viking Corporation.

A. Description:
1. Standard: UL 312 and FM Global standard for swing check valves, Class Number 1210.

2. Minimum Pressure Rating: 175 psig.
3. Type: Single swing check.
4. Body Material: Cast iron, ductile iron, or bronze.
5. Clapper: Bronze, ductile iron, or stainless steel with elastomeric seal.
6. Clapper Seat: Brass, bronze, or stainless steel.
7. Hinge Shaft: Bronze or stainless steel.
8. Hinge Spring: Stainless steel.
9. End Connections: Flanged, grooved, or threaded.

2.6 BRONZE OS&Y GATE VALVES

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:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Milwaukee Valve Company.
   c. NIBCO INC.
   d. United Brass Works, Inc.

B. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Bronze or brass.
4. Wedge: One-piece bronze or brass.
5. Wedge Seat: Bronze.
6. Stem: Bronze or brass.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Threaded.

2.7 IRON OS&Y GATE VALVES

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:
   a. American Cast Iron Pipe Company; Waterous Company Subsidiary.
   b. American Valve, Inc.
   c. Clow Valve Company; a division of McWane, Inc.
   d. Crane Co.; Crane Valve Group; Crane Valves.
   e. Hammond Valve.
   f. Milwaukee Valve Company.
   g. Mueller Co.; Water Products Division.
   h. NIBCO INC.
   i. Shurjoint Piping Products.
   j. Tyco Fire & Building Products LP.
   k. United Brass Works, Inc.
   l. Watts Water Technologies, Inc.

A. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron, or bronze with elastomeric coating.
5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Flanged, Grooved, or Threaded.

2.9 INDICATOR POSTS

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:
   a. NIBCO, Inc.
   b. Clow Valve Company; a division of McWane, Inc.
   c. Kennedy Valve; a division of McWane, Inc.
   d. Mueller Co.; Water Products Division.

A. Description:
1. Standard: UL 789 and FM Global standard for indicator posts.
2. Type: Underground, Pit or Wall.
3. Base Barrel Material: Cast or ductile iron.
4. Extension Barrel: Cast or ductile iron.
5. Cap: Cast or ductile iron.
6. Operation: Handwheel.

2.10TRIM AND DRAIN VALVES

A. Ball Valves:
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:
   a. Affiliated Distributors.
   b. Anvil International, Inc.
   c. Barnett.
   d. Conbraco Industries, Inc.; Apollo Valves.
   e. Fire-End & Croker Corporation.
   f. Fire Protection Products, Inc.
   g. Flowserve.
   h. FNW.
   i. Jomar International, Ltd.
   j. Kennedy Valve; a division of McWane, Inc.
   k. Kitz Corporation.
   l. Legend Valve.
   m. Metso Automation USA Inc.
   n. Milwaukee Valve Company.
   o. NIBCO INC.
   p. Potter Roemer.
   q. Red-White Valve Corporation.
   r. Southern Manufacturing Group.
2. Description:
   a. Pressure Rating: 175 psig.
   b. Body Design: Two piece.
   c. Body Material: Forged brass or bronze.
   d. Port size: Full or standard.
   e. Seats: PTFE.
   f. Stem: Bronze or stainless steel.
   g. Ball: Chrome-plated brass.
   h. Actuator: Handlever.
   i. End Connections for Valves NPS 1 through NPS 2-1/2: Threaded ends.
   j. End Connections for Valves NPS 1-1/4 and NPS 2-1/2: Grooved ends.

B. Angle Valves:
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:
   a. Fire Protection Products, Inc.
   b. United Brass Works, Inc.
2. Description:
   a. Pressure Rating: 175 psig.
   b. Body Material: Brass or bronze.

c. Ends: Threaded.
d. Stem: Bronze.
e. Disc: Bronze.
f. Packing: Asbestos free.
g. Handwheel: Malleable iron, bronze, or aluminum.

C. Globe Valves:
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:
a. Fire Protection Products, Inc.
b. United Brass Works, Inc.
2. Description:
a. Pressure Rating: 175 psig.
b. Body Material: Bronze with integral seat and screw-in bonnet.
c. Ends: Threaded.
d. Stem: Bronze.
e. Disc Holder and Nut: Bronze.
f. Disc Seat: Nitrile.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 GENERAL REQUIREMENTS FOR VALVE INSTALLATION

A. Comply with requirements in the following Sections for specific valve installation requirements and applications:
1. Section 211313 "Wet-Pipe Sprinkler Systems" for application of valves in wet-pipe, fire-suppression sprinkler systems.

B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Install valves having threaded connections with unions at each piece of equipment arranged to allow easy access, service, maintenance, and equipment removal without system shutdown. Provide separate support where necessary.

E. Install valves in horizontal piping with stem at or above the pipe center.

F. Install valves in position to allow full stem movement.

G. Install valve tags. Comply with requirements in the NFPA standard applying to the piping system in which valves are installed. Install permanent identification signs indicating the portion of system controlled by each valve.

END OF SECTION 210523

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SECTION 211119 - FIRE DEPARTMENT CONNECTIONS

PART 1- GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Exposed-type fire-department connections.

B. Related Requirements:
   1. Section 210523 "General-Duty Valves for Water-Based Fire-Suppression Piping."
   2. Section 211313 “Wet-pipe Sprinkler Systems” for wet-pipe sprinkler piping.
   3. Section 210500 “Fire Protection Firestopping”.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each fire-department connection.

PART 2 – PRODUCTS

2.1 FLUSH-MOUNTED FIRE DEPARTMENT CONNECTIONS

A. Description: Flush fire department connection for wall mounting, made of corrosion-resistant metal, and complying with UL 405.

   1. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged non-swivel connection, and check devices or clappers.

   2. Body Style: Horizontal.

   3. Caps: Brass, lugged type with gasket and chain.

   4. Finish: Rough brass or bronze.

   5. Pressure Rating: 300 psig minimum.

   6. Number of Inlets: Two.

   7. Inlet Size: 2 1/2-inches NPS.

   8. Outlet Location: Back.

   9. Escutcheon Plate: Circular, brass, wall type.

   Escutcheon Plate Marking: Similar to "AUTO SPKR”.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions, with installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of fire-department connections.

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

3.2 INSTALLATION

A. Install wall-type fire-department connections.

B. Install automatic (ball-drip) drain valve at each check valve for fire-department connection.

END OF SECTION 211119

SECTION 211313 - WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Pipes, fittings, and specialties.
2. Fire-protection valves.
3. Specialty valves.
4. Sprinklers.
5. Alarm devices.
6. Pressure gauges.

B. Related Requirements:
1. Section 210523 "General-Duty Valves for Water-Based Fire-Suppression Piping."
2. Section 211119 "Fire-Department Connections" for exposed wall-mounted and yard fire hydrants.
3. Section 210500 “Fire Protection Firestopping”.

1.3 DEFINITIONS

A. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175-psig maximum.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For sprinkler systems.
1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For automatic sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer or NICET III/IV (Water-Based Systems Layout) fire protection designer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Sprinkler systems, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Plumbing piping.
2. HVAC hydronic piping.
3. Items penetrating finished ceiling include the following:
a. Lighting fixtures.

b. Air outlets and inlets.
c. Fire alarm devices.
4. HVAC ductwork.

B. Qualification Data: For qualified installer and professional engineer.

C. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations.

D. Welding certificates.

E. Fire-hydrant flow test report.

F. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."

G. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wet-pipe sprinkler systems and specialties to include in emergency, operation, and maintenance manuals.

B. As-built sprinkler drawings and hydraulic calculations.

C. One copy of NFPA 25, current edition.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrenches. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

1.8 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer or NICET III/IV (Water-Based Systems Layout) Fire Protection Designer.

B. Welding Qualifications: Qualify procedures and operators according to 2010 ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:
   1. 2013 NFPA 13.
   2. 2018 North Carolina State Building Code.
   3. 2018 North Carolina Fire Code.

B. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.

C. Delegated Design: Engage a qualified professional engineer, or NICET III/IV (Water Based Systems Layout) Fire Protection Designer, to design wet-pipe sprinkler systems.
   1. Available fire-hydrant flow test records indicate the following conditions:
      a. Date: 05/07/2024.
      b. Time: 9:00 am.
      c. Performed by: Fort Township Sanitary District.
      d. Static Pressure: 60 psig.
      e. Measured Flow at Flow Fire Hydrant F: 1,008 gpm.
      f. Residual Pressure: 47 psig.
   2. Sprinkler system design shall be approved by authorities having jurisdiction.
      a. Margin of Safety for Available Water Flow and Pressure: 10 psi, including losses through water-service piping, valves, and backflow preventers.
      b. Sprinkler Occupancy Hazard Classifications:
         1) Building Service Areas: Ordinary Hazard, Group 1.
         2) Cafeteria: Light Hazard.
         3) Chemical Storage Rooms: Ordinary Hazard, Group 2.
         4) Classrooms: Light Hazard.
         5) Electrical Equipment Rooms: Ordinary Hazard, Group 1.
         6) Food Prep: Ordinary Hazard, Group 1.
         7) General Storage Areas: Ordinary Hazard, Group 2.
         8) Gymnasium: Light Hazard.
         9) Kitchen: Ordinary Hazard, Group 1.
         10) Media Center: Light Hazard.
         11) Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
         12) Office and Public Areas: Light Hazard.
         13) Storage: Ordinary Hazard, Group 2.
         14) Auditorium: Light Hazard.
         15) All other areas: Per NFPA-13 requirements.
   3. Minimum Density for Automatic-Sprinkler Piping Design:
      a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft.
      b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft.
      c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft.
   4. Maximum Protection Area per Sprinkler: According to UL listing.
   5. Maximum Protection Area per Sprinkler:
      a. Light-Hazard: 225 sq. ft.
      b. Ordinary-Hazard Group 1: 130 sq. ft.
      c. Ordinary-Hazard Group 2: 130 sq. ft.
      d. Extended coverage protection areas: According to manufacturer’s guidelines and NFPA 13 requirements.

2.2 STEEL PIPE AND FITTINGS

A. Standard-Weight, Black-Steel Pipe: ASTM A 53, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

B. Thinwall Black-Steel Pipe: ASTM A 135 or ASTM A 795, with wall thickness less than Schedule 30 and equal to or greater than Schedule 10. Pipe ends may be factory or field formed to match joining method.

C. Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53, standard-weight, seamless steel pipe with threaded ends.

D. Uncoated-Steel Couplings: ASTM A 865, threaded.

E. Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

F. Malleable- or Ductile-Iron Unions: UL 860.

G. Cast-Iron Flanges: ASME 16.1, Class 125.

H. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8-inch thick, ASME B16.21, nonmetallic and asbestos free or EPDM rubber gasket.
    a. Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
    b. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.
2. Metal, Pipe-Flange Bolts and Nuts: Carbon steel unless otherwise indicated.

I. Steel Welding Fittings: ASTM A 234 and ASME B16.9.
1. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

J. Grooved-Joint, Steel-Pipe Appurtenances:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
    a. Anvil International, Inc.
    b. Shurjoint Piping Products.
    c. Tyco Fire & Building Products LP.
    d. Victaulic Company.
2. Pressure Rating: 175-psig minimum.
3. Grooved-End Fittings for Steel Piping: ASTM A 47, malleable-iron casting or ASTM A 536, ductile-iron casting, with dimensions matching steel pipe.
4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.3 SPECIALTY VALVES

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

B. Pressure Rating:
1. Standard-Pressure Piping Specialty Valves: 175-psig minimum.

C. Body Material: Cast or ductile iron.

D. Size: Same as connected piping.

E. End Connections: Flanged or grooved.

A. Alarm Valves:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
    a. Reliable Automatic Sprinkler Co., Inc.
    b. Tyco Fire & Building Products, LP.

c. Viking Corp.

B. Automatic (Ball Drip) Drain Valves:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
a. AFAC Inc.
b. Reliable Automatic Sprinkler Co., Inc.
c. Tyco Fire & Building Products, LP.
d. Viking Corp.
e. Nibco.
2. Standard: UL 1726.
3. Pressure Rating: 175-psig minimum.
4. Type: Automatic draining, ball check.
5. Size: NPS 3/4.
6. End Connections: Threaded.

2.4 SPRINKLER PIPING SPECIALTIES

A. Branch Outlet Fittings:
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:
a. Anvil International, Inc.
b. National Fittings, Inc.
c. Shurjoint Piping Products.
d. Tyco Fire & Building Products LP.
e. Victaulic Company.
2. Standard: UL 213.
3. Pressure Rating: 175-psig minimum.
4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
5. Type: Mechanical-tee and -cross fittings.
6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
8. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:
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:
a. AGF Manufacturing Inc.
b. Reliable Automatic Sprinkler Co., Inc.
c. Tyco Fire & Building Products LP.
d. Victaulic Company.
2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
3. Pressure Rating: 175-psig minimum.
4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded or grooved.

C. Sprinkler Inspector's Test Fittings:
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:
a. AGF Manufacturing Inc.
b. Triple R Specialty.
c. Tyco Fire & Building Products LP.
d. Victaulic Company.
e. Viking Corporation.
2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

3. Pressure Rating: 175-psig minimum.
4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

2.5 SPRINKLERS

A. 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:
1. Reliable Automatic Sprinkler Co., Inc.
2. Tyco Fire & Building Products LP.
3. Victaulic Company.
4. Viking Corporation.

B. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

C. Pressure Rating for Automatic Sprinklers: 175-psig minimum.

D. 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 or 8.0, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

E. Sprinkler Finishes: Painted white and bronze.

F. Special Coatings: Electroless Nickel PTFE.

G. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
1. Ceiling Mounting:
a. Steel, two-piece, semi-recessed with 1/2-inch vertical adjustment.
b. Steel, 1-piece, flat plate concealed.
2. Sidewall Mounting:
a. Steel, two-piece, semi-recessed.

H. Sprinkler Guards:
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:
a. Reliable Automatic Sprinkler Co., Inc.
b. Tyco Fire & Building Products LP.
c. Victaulic Company.
d. Viking Corporation.
2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

2.6 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Electrically Operated Alarm Bell:
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:
a. Fire-Lite Alarms, Inc.; a Honeywell company.
b. Notifier; a Honeywell company.
c. Potter Electric Signal Company.
d. Viking Corp.

2. Standard: UL 464.
3. Type: Vibrating, metal alarm bell.
4. Size: 8-inch diameter.
5. Finish: Red-enamel factory finish, suitable for outdoor use.
6. 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. Water-Flow Indicators:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
   a. System Sensor.
   b. Potter Electric Signal Co.
2. Standard: UL 346.
3. Water-Flow Detector: Electrically supervised.
4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
5. Type: Paddle operated.
6. Pressure Rating: 250 psig.
7. Design Installation: Horizontal or vertical.

D. Pressure Switches:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
   a. System Sensor.
   b. Potter Electric Signal Co.
2. Standard: UL 346.
3. Type: Electrically supervised water-flow switch with retard feature.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design Operation: Rising pressure signals water flow.

E. Valve Supervisory Switches:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
   a. System Sensor.
   b. Potter Electric Signal Co.
2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled valve is in other than fully open position.

F. Indicator-Post Supervisory Switches:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
   a. System Sensor.
   b. Potter Electric Signal Co.
2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled indicator-post valve is in other than fully open position.

2.7 PRESSURE GAUGES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
1. Ashcroft, Inc.
2. Viking Corp.

3. AMETEK, U.S. Gauge Division.

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch diameter.

D. Pressure Gauge Range: Zero to 250 psig minimum.

E. Water System Piping Gauge: Include "WATER" or "AIR/WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.

B. Report test results promptly and in writing.

3.2 SERVICE-ENTRANCE PIPING

A. Connect sprinkler piping to water-service piping for service entrance to building.

B. Install shutoff valve, backflow preventer, pressure gauge, drain, and other accessories indicated at connection to water-service piping.

3.3 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated on approved working plans.
   1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
   2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

B. Piping Standard: Comply with NFPA 13 requirements for installation of sprinkler piping.

C. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

D. Install unions adjacent to each valve in pipes NPS 2 and smaller.

E. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

F. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.

G. Install sprinkler piping with drains for complete system drainage.

H. Install sprinkler piping a minimum of ten (10) feet away from electrical switchboards and panel boards.

I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

J. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.

K. Install alarm devices in piping systems.

L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.

M. Install pressure gauges on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gauges with connection not less than NPS 1/4 and with soft-metal seated globe valve, arranged for draining pipe between gauge and valve. Install gauges to permit removal and install where they are not subject to freezing.

N. Fill sprinkler system piping with potable water.

O. Install metallic pipe sleeves for piping penetrations of all walls, partitions, and slabs. Refer to section 210500 for penetrations through fire-rated assemblies.

P. Install chrome escutcheon rings for exposed piping penetrations of walls, ceilings, and floors.

Q. Install head guards on all sprinklers located below 7’-6” above the finished floor and in areas subject to being hit by flying objects such as gymnasiums, mechanical rooms, and multipurpose rooms.

R. Reducing couplings shall not be used.

3.4 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Twist-Locked Joints shall not be used.

I. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
   1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

J. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

K. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

L. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

M. Reducing couplings shall not be used.

3.5 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:
1. Install valves in vertical position for proper direction of flow, in main supply to system.
2. Install alarm valves with bypass check valve and retarding chamber drain-line connection.

3.6 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels.

B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.

3.7 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

B. Identify system components, wiring, cabling, and terminals.

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Coordinate with fire-alarm tests. Operate as required.
6. Coordinate with fire-pump tests. Operate as required.
7. Verify that equipment hose threads are same as local fire department equipment.

B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.9 CLEANING

A. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are dirty, painted or have any other finish than their original factory finish.

3.10 DEMONSTRATION

A. Train owner's maintenance personnel to adjust, operate, and maintain specialty valves and pressure-maintenance pumps.

3.11 PIPING SCHEDULE

A. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with or grooved ends, grooved-end fittings, grooved-end-pipe couplings, and grooved joints.

B. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.

C. Standard-pressure, wet-pipe sprinkler system, NPS 1-1/2 and smaller, shall be the following:
1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.

D. Standard-pressure, wet-pipe sprinkler system, NPS 2 to NPS 8, shall be the following:
1. Schedule 10, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.12 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:
1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings 9’-0 or less: Flat Plate Concealed sprinklers.
3. Rooms with Gypsum Ceilings: Flat Plate Concealed sprinklers.
4. Rooms with Suspended Ceilings greater than 9’-0: Semi-recessed sprinklers.
5. Wall Mounting: Sidewall sprinklers.
6. Spaces Subject to Freezing: pendent, dry sprinklers; and sidewall, dry sprinklers as indicated. Dry pendents to have insulated boot.

B. Provide sprinkler types in subparagraphs below with finishes indicated.
1. Concealed Sprinklers: Rough brass, with factory-finish White cover plate.
2. Recessed Sprinklers: Factory-painted Chrome plated, with Chrome plated escutcheon.
3. Upright and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; Electroless Nickel PTFE coated where exposed to acids, chemicals, shower rooms or other corrosive fumes.

END OF SECTION 211313

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SECTION 220100 – PLUMBING GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1. STIPULATIONS

A. General provisions of the contract documents including general and supplementary conditions apply to all work in this division.

B. The general conditions shall be carefully examined before proposals for any work are submitted. Division twenty-two shall not be interpreted as waiving or overruling any requirements expressed in the general conditions unless division twenty-two specifications contain statements more definitive or more restrictive.

C. Nothing herein contained shall be so construed as to relieve the contractor from performing their work according to the true intent and meaning of the contract drawings and specifications. The contractor will be held responsible to provide all materials and equipment and shall provide all labor necessary for the complete, prompt, and satisfactory execution of the work. The contractor is also responsible for the proper coordination of their work with all other trades.

D. The contractor shall bear all expenses incidental to the satisfactory completion of the work contained in the contract drawings and specifications.

1.2. DEFINITIONS

A. Where words and phrases used throughout the contract documents are not specifically defined on the documents or in the reference standards, they shall be interpreted by the meanings given to them in the latest edition of the Merriam-Webster dictionary.

B. Words and phrases used throughout the contract documents shall be interpreted as indicated below:

1. Concealed, exterior installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures.

2. Concealed, interior installations: Concealed from view and protected from physical contact by building occupants.

3. Contractor: The person or organization awarded the contract for construction services. In the case of a construction project administered as a multiple-prime contract, the term shall be further defined as the contractor holding a prime contract for plumbing construction work.

4. Exposed, exterior installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions.

5. Exposed, interior installations: Exposed to view indoors.

6. Finished spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, tunnels, or similar spaces where building occupants do not regularly spend time.

7. Furnish items to owner or others: Contractor shall select, purchase, and deliver materials, equipment, or systems for installation by the owner or others.

8. Install items furnished by owner or others: The contractor shall receive shipment, store, install, and verify materials, equipment, or systems selected and purchased outside of their construction contract.

9. Occupancy, further defined as follows:

    a. Full owner occupancy: Owner will occupy the areas of work during the entire construction period.

    b. Partial owner occupancy: Owner may occupy completed areas of work before owner acceptance.

10. Others: A person or organization other than the contractor, owner, or professional.

11. Owner: The person or organization that awards the construction contract, or their designated representative.

12. Owner acceptance or substantial completion: Work that is judged by the professional to be substantially complete, accepted to be safe for use by the authority having jurisdiction, and accepted by the Owner. Acceptance comes with an agreement that the professional's written punchlist of outstanding items will be completed to fulfill the contractual obligations.

13. Professional: The engineer of record.

14. Provide: To furnish and install materials, equipment, or systems.

15. Submittals: Industry standards, manufacturer's data, manufacturer's warranties, operation and maintenance instructions, shop drawings, and test reports.

16. Work: All labor, materials, equipment, and services necessary and reasonably incidental to the proper completion and proper operation of the plumbing systems.

1.3. REFERENCES

A. The contractor shall comply with all laws, ordinances, and regulations of all authorities having jurisdiction, including those of all applicable city, county, state, federal, and public utility entities.

B. The publications listed below form a part of this specification. All publications shall be the latest edition as adopted by the authority having jurisdiction at the date of bid advertisement. The minimum standard of work under this contract shall be in accordance with the following model building codes or standards:

1. ASTM International:

    a. ASTM C33 – Standard Specification for Concrete Aggregates.

    b. ASTM C94 – Standard Specification for Ready-Mixed Concrete.

    c. ASTM C150 – Standard Specification for Portland Cement.

    d. ASTM C177 – Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.

    e. ASTM C618 – Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.

    f. ASTM C989 – Standard Specification for Slag Cement for Use in Concrete and Mortars.

    g. ASTM D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3).

    h. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.

2. International Building Code (IBC) with North Carolina Amendments:

a. North Carolina Building Code.

b. North Carolina Energy Conservation Code.

c. North Carolina Fire Prevention Code.

d. North Carolina Fuel Gas Code.

e. North Carolina Mechanical Code.

f. North Carolina Plumbing Code.

3. National Fire Protection Association:

a. NFPA 70 – National Electric Code.

4. National Sanitation Foundation:

a. NSF 14 – Plastic Piping System Components.

1.4. RELATED WORK

A. The contractor shall obtain all licenses, permits, etc. and shall pay all associated connection fees, tapping fees, inspection fees, etc. These costs shall be included in the contract price.

B. All work related to providing complete plumbing systems and equipment shall be the responsibility of the contractor. The following related work shall be provided as indicated in other specification divisions:

1. Electrical contractor:

a. Verification of the proper rotation of three-phase equipment, and any modifications required to correct improper rotation.

b. Installation of all combination starters and/or disconnects and overload protection devices.

c. Installation of all line-side wiring and junction boxes and/or receptacles supplying fire protection equipment.

2. General contractor:

a. Installation of access panels.

b. Concrete housekeeping and structural pads for equipment.

c. Gutters and downspouts.

d. Catch basins and foundation drains. Any required final connections shall be by the contractor only where indicated on the drawings and within division twenty-two specifications.

e. Concrete retaining collars, bases, anchors, etc. for buried interceptors, receivers, and tanks.

f. Cast-in-place concrete interceptors, receivers, tanks, and sumps.

g. The contractor shall furnish roof drains to the general contractor for installation in roofs. The contractor shall make final connections to roof drains.

h. The contractor shall furnish a four- (4) feet long section of vent piping to the general contractor for each vent terminal installed in roofs. The contractor shall make final connections to vent terminals.

i. The contractor shall make all final connections to owner supplied equipment. The contractor shall be responsible for coordination of plumbing services with the equipment.

j. The contractor shall furnish and/or install casework-mounted fixtures and equipment where not furnished and/or installed by others. Where fixtures and equipment are furnished by others, the contractor shall install these items in accordance with the contract drawings and specifications. Rough-in plumbing work shall be in accordance with rough-in drawings provided by others. The contractor shall make the final connections to all such fixtures and equipment. The contractor shall be responsible for coordination of plumbing services with the fixtures and equipment.

k. Cutting and patching: The general contractor shall perform cutting and patching of floor slabs-on-grade, exterior walls, and roofs when necessary for the installation of the work. All costs associated for this work shall be paid by the contractor.

l. Painting: The general contractor shall perform all required painting of piping provided by the contractor.

3. Mechanical contractor:

a. Mechanical makeup water connections downstream of contractor provided backflow prevention devices.

b. Condensate drain piping associated with mechanical equipment to waste receptors provided by the contractor.

c. The contractor shall install pipeline mounted metering and control devices furnished by the mechanical contractor for connection to the building automation system, or similar monitoring system(s), located in systems provided by the contractor. All control wiring shall be provided by the mechanical contractor.

1.5. QUALITY ASSURANCE

A. The contractor shall become thoroughly familiarized with all specifications and drawings for the project so that they clearly understand their responsibility in relationship to the work to be performed. The contractor shall plan and perform their work to permit the use of the building at the earliest possible date.

B. Changes from the contract documents necessary to coordinate the work with other trades, to conform to the building conditions, or to conform to the rules and regulations of authorities having jurisdiction shall be made only after obtaining written permission from the professional.

C. The contractor is responsible for the proper installation of all materials and equipment required for a complete installation within the intent and meaning of the contract documents.

D. The contractor shall expressly and completely follow manufacturer’s instructions required for validation of the manufacturer’s warranty agreement including but not limited to service, maintenance, and adjustments of the equipment.

E. The contractor shall guarantee all work, materials, and equipment furnished against defects, leaks, performance, and non-operation for a period of one (1) year after the date of the owner’s acceptance, or as indicated in the general conditions. Defects shall be interpreted as defective materials or equipment or unsatisfactory installation and are not intended to apply to ordinary wear and tear. The contractor shall pay for any repairs or replacements caused by these defects within the period covered by the guarantee, including all incidental work required to fix the deficiency.

1.6. MATERIALS

A. Each length of pipe and each pipe fitting, trap, fixture, material, and device utilized in all plumbing systems shall bear the identification of the manufacturer and the applicable standard to which it was manufactured.

1. Nipples created from the cutting and threading of approved pipe shall not be required to be identified.

2. Where the manufacturer identification cannot be marked on pipe fittings and pipe nipples because of the small size of such fittings, the identification shall be printed on the item packaging or on documentation provided with the item.

B. All materials used shall be installed in strict accordance with the standards under which the materials are accepted and approved. In the absence of such installation procedures, the manufacturer's instructions shall be followed. Where the requirements of referenced standards or manufacturer's installation instruction do not conform to the minimum provisions of the North Carolina Plumbing Code, the provisions of the North Carolina Plumbing Code shall apply.

C. All plastic pipe, fittings, and components shall be third-party certified as conforming to NSF 14.

D. All plumbing products and materials shall be listed by a third-party certification agency as complying with the referenced standards.

E. All piping materials exposed within plenums shall comply with the provisions of the International Mechanical Code.

F. Equipment efficiencies shall be in accordance with the North Carolina Energy Conservation Code.

G. Solders with lead content exceeding two-tenths (0.2) percent are prohibited. Brass and bronze materials with lead content two (2) percent or greater are prohibited.

H. Provide products requiring electrical connections listed and labeled by Underwriters Laboratories, Inc. (UL), as suitable for the purpose specified and indicated.

1.7. FIELD MEASUREMENTS

A. The contractor is responsible to verify the location of any and all existing underground utilities in the vicinity of their work. When it has been indicated that these utilities are to remain in place, the contractor shall provide adequate means of support and protection during excavation operations.

B. Before ordering any equipment and material, or performing any work, the contractor shall verify all measurements and dimensions in the areas of work. The contractor is responsible for the correctness of this information.

C. Any difference identified by the contractor shall be submitted to the professional for consideration before proceeding with the work.

D. No extra compensation will be considered based on differences between actual dimensions and measurements and those indicated on the drawings.

1.8. PROTECTION OF UTILITIES

A. All existing service utilities shall remain active during construction. Any service underground, aboveground, interior, or exterior damaged, broken, or otherwise rendered inoperative during the completion of the work due to activities on the part of the contractor shall be properly repaired by the contractor at their own expense. The method used in repairing, replacing, or maintaining the services shall be submitted to the professional for review and approval.

B. Ashes, cinders or rags; flammable, poisonous or explosive liquids or gases; oil, grease or any other insoluble material capable of obstructing, damaging or overloading the building drainage or sewer system, or capable of interfering with the normal operation of the sewage treatment process or private disposal system, shall not be deposited into such systems.

C. Waste products from manufacturing or industrial operations shall not be introduced into the public sewer until it has been determined by the code official or other authority having jurisdiction that the introduction thereof will not damage the public sewer system or interfere with the functioning of the sewage treatment plant.

1.9. INTERRUPTION OF UTILITIES

A. The contractor shall schedule their work to avoid interruption of any utility services.

B. Existing utilities serving occupied facilities shall not be interrupted except when such interruptions have been authorized by the owner. Interruptions may occur only after acceptable temporary utility services have been provided. The contractor shall provide a minimum of seventy-two (72) hours' notice to the owner and receive written notice to proceed before interrupting any utility.

1.10. STRUCTURAL SAFETY

A. The work shall be installed with due regard to preservation of the strength of structural members and prevention of damage to walls and other surfaces through fixture usage.

B. In the process of installing or repairing any part of a plumbing system, the finished floors, walls, ceilings, tile work, or any other part of the building or premises that must be changed or replaced shall be left in a safe structural condition in accordance with the International Building Code.

C. The cutting, notching, and boring of holes in structural steel framing members shall be as prescribed by the structural engineer.

D. Flanges and lips of load-bearing cold-formed steel framing members shall not be cut or notched. Holes in webs of load-bearing cold-formed steel framing members shall be permitted along the centerline of the web of the framing member and shall not exceed the dimensional limitations, penetration spacing, or minimum hole edge distance as prescribed by the structural engineer. Cutting, notching, and boring holes of steel floor or roof decking shall be as prescribed by the structural engineer.

E. Flanges and lips of nonstructural cold-formed steel wall studs shall not be cut or notched. Holes in webs of nonstructural cold-formed steel wall studs shall be permitted along the centerline of the web of the framing member, shall not exceed one (1) inch in width or four (4) inches in length, and the holes shall not be spaced less than twenty-four (24) inches center to center from another hole or less than ten (10) inches from the bearing end.

F. Truss members and components shall not be cut, drilled, notched, spliced, or otherwise altered in any way without written concurrence and approval of the structural engineer. Alterations resulting in the addition of loads to any member shall not be permitted without verification that the truss is capable of supporting such additional loading.

G. Trenches installed parallel to footings shall not extend below the forty-five (45) degree bearing plane of the footing or wall. The upper boundary of the bearing plan is a line that extends downward, at an angle of forty-five (45) degrees from horizontal, from the outside bottom edge of the footing or wall.

1.11. RODENTPROOFING

A. All strainer plates on drain inlets shall be designed and installed so that all openings are not greater than one-half (1/2) inch in least dimension.

B. Where openings have been made in walls, floors, or ceilings for the passage of pipes, the annular space between the pipe and the sides of the opening shall be sealed with materials compatible with the piping materials and locations by the use of collars or caulking materials or gasket systems.

1.12. PROTECTION OF WORK

A. Plumbing systems shall not be located in an elevator shaft or in an elevator equipment room. Floor drains, sumps, and sump pumps shall be permitted at the base of an elevator shaft when intended for the specific purpose of dewatering and are installed in accordance with the contract documents.

B. Pipes passing through concrete or cinder walls and floors or other corrosive material shall be protected against external corrosion by a protective sheathing or wrapping or other means that will withstand any reaction from the lime and acid of concrete, cinder, or other corrosive material. Sheathing or wrapping shall allow for movement including expansion and contraction of piping. The wall thickness of the material shall be not less than twenty-five-thousandths (0.025) inch.

C. Piping in a plumbing system shall be installed so as to prevent strains and stresses that exceed the structural strength of the pipe. Where necessary, provisions shall be made to protect piping from damage resulting from expansion, contraction, and structural settlement.

D. Any pipe that passes within twelve (12) inches of the bottom of the footing or through a foundation wall shall be provided with a relieving arch, or a pipe sleeve pipe. Pipe sleeves for foundation walls shall be built into the foundation wall. The sleeve shall be two (2) pipe sizes greater than the pipe passing through the wall. Piping shall not be run under pier footings. Annular spaces between sleeves and pipes shall be filled or tightly sealed in an approved manner. Annular spaces between sleeves and pipes in fire-resistance-rated assemblies shall be filled or tightly sealed in accordance with the North Carolina Building Code. Only sleeves through foundation or exterior building walls shall be sealed on both sides.

E. Water pipes installed in a wall exposed to the exterior shall be located on the heated side of the wall insulation. Water and waste pipes shall not be installed outside of a building, in unconditioned attics, unconditioned utility rooms, or in any place subjected to freezing temperatures unless adequate provision is made to protect such pipes from freezing by a minimum of R6.5 insulation determined at 75 °F in accordance with ASTM C177 or heat or both. Exterior water supply system piping shall be installed not less than six (6) inches below the frost line and not less than twelve (12) inches below grade.

F. No traps of waste pipe shall be installed or permitted outside of a building, or concealed in outside walls, or in any place where they may be subjected to freezing temperatures, unless approved provisions are made to protect them from freezing.

G. In concealed locations where piping, other than cast iron or galvanized steel, is installed through holes or notches in studs, joists, rafters, or similar members less than one-and-one-half (1-1/2) inches from the nearest edge of the member, the pipe shall be protected by steel shield plates. Such shield plates shall have a thickness of not less than sixteen (16) gage. Such plates shall cover the area of the pipe where the member is notched or bored, and shall extend not less than two (2) inches above sole plates and below top plates.

H. Components of plumbing systems installed along alleyways, driveways, parking garages, or other locations exposed to damage shall be recessed into the wall or otherwise protected in an approved manner.

I. At their own expense, the contractor shall protect their work, materials, or equipment that is subject to damage during the project duration. All openings into any piping, ducts, or equipment shall be securely covered, or otherwise protected, to prevent injury due to carelessly or maliciously dropped tools or materials, grit, dirt, or any foreign material. The contractor is responsible for all damage until their work is fully and finally accepted.

J. The use of plumbing fixtures prior to final acceptance by the owner is prohibited.

1.13. CHASES AND OPENINGS

A. All chases and openings required for the installation of the work shall be coordinated with the work of other trades. The contractor shall provide the other trades with sufficient time for coordination of all chases and openings. The contractor shall be responsible for cutting and patching all openings in walls and partitions necessary for the work.

B. The contractor shall provide all sleeves, hangers, and anchors required for installation of the work in chases and openings.

1.14. MISCELLANEOUS STEEL AND ACCESSORIES

A. The contractor shall provide all necessary steel angles, channels, pipe, rods, nuts, bolts, etc. as shown on plans, as specified, or as may be required for complete and proper installation of the work. All material and workmanship shall be of the best quality and shall be installed in accordance with the best practices of the trade.

1.15. CROSS CONNECTION CONTROL

A. The contractor shall coordinate water service requirements in accordance with the local water utility regulations, including required permits, backflow preventers, meters, piping, valves, bypasses, supports, and other accessories.

B. Where these services are provided by others, the contractor shall verify that they are complete and have been inspected prior to making final connection(s).

1.16. CLEANUP

A. The contractor shall provide containers for collection of waste materials, debris, and rubbish. Waste materials, debris, and rubbish shall be removed from the job site and legally disposed of at a landfill area in accordance with all applicable regulations. Burning or burying waste materials, debris, or rubbish on project site is not permitted.

B. The contractor shall maintain buildings, grounds, and public properties free from accumulations of waste materials, debris, and rubbish. At reasonable intervals during the progress of work, and when directed by the owner, the site and public properties shall be cleaned and waste materials, debris, and rubbish disposed of in an appropriate manner.

C. At the completion of the project, the contractor shall remove waste materials, rubbish, tools, equipment, machinery, surplus materials, etc., and clean all sight-exposed accessories and equipment; remove grease, dust, dirt, stains, labels, fingerprints, and other foreign materials from sight-exposed accessories and equipment; broom clean paved and concrete surfaces; rake clean other ground surfaces; repair, patch, and touch-up marred surfaces to the specified finish or to match adjacent surfaces.

1.17. PROJECT CLOSEOUT DOCUMENTATION

A. Changes from the contract documents necessary to coordinate the work with other trades, to conform to the building conditions, or to conform to the rules and regulations of authorities having jurisdiction shall be made only after obtaining written permission from the professional.

B. The contractor shall keep a record of construction changes and deviations from the original contract documents. All changes shall be recorded on a separate set of prints, which shall be kept at the project site specifically for that purpose. The record shall be made immediately after the work is completed. Documentation shall include:

1. Location and elevation of new utility lines.

2. Changes in pipe size and routing location.

3. Valve locations.

4. Equipment locations.

5. Actual capacities and values of equipment provided.

C. The marked-up record set of construction documents shall be delivered to the professional after final acceptance of the work.

D. The contractor shall deliver operation and maintenance manuals per section 22 01 05 to the professional before instruction of the owner and after final acceptance of the work.

1.18. INSTRUCTION OF THE OWNER

A. After acceptance of the project, the contractor shall furnish the services of personnel thoroughly familiar with the completed installation to instruct the owner in the proper operation and maintenance of all equipment and appurtenances provided.

B. The contractor shall provide the owner with ten (10) business days' notice before the instruction session(s).

PART 2 - PRODUCTS

2.1. ACCESS PANELS

A. Access panels shall be of sufficient size to permit access, except that the minimum size shall be twelve (12) inches by sixteen (16) inches.

B. Access doors shall be suitable for installation in the finish material of the ceiling, wall, partition, or floor in which they are installed.

C. Access doors with an Underwriter's Laboratory listing shall be provided in fire-resistance-rated construction assemblies. Access doors shall have a fire-resistance rating of no less than that required by the listing of the assembly in which they are installed. Maximum size shall be twenty (20) inches by twenty (20) inches or four hundred (400) square inches in area. Frame shall be sixteen (16) gauge minimum steel, panel shall be twenty (20) gauge minimum steel.

D. Access doors without an Underwriter's Laboratory label shall be provided in all non-rated construction assemblies. Frame shall be sixteen (16) gauge minimum steel, panel shall be fourteen (14) gauge minimum steel.

E. Frames and panels for access doors in restrooms, kitchens, and as indicated shall be stainless steel.

F. Access doors shall be provided with a baked-on enamel finish (prime coat), concealed spring type hinges, flush-face type lock with key operation, and self-latching cylinder locks.

G. Access doors shall open a minimum of one-hundred-seventy-five (175) degrees.

H. All access doors shall be keyed alike. Coordinate locking mechanism type with owner prior to purchase and installation.

2.2. SLEEVES

A. Cast iron wall pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized steel wall pipes: ASTM A53, schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized steel pipe sleeves: ASTM A53, type E, grade B, schedule 40, zinc coated, with plain ends.

D. Galvanized steel sheet sleeves: Minimum 20-gauge thickness; round tube closed with welded longitudinal joint.

E. Polyvinyl chloride (PVC) pipe sleeves are not acceptable.

2.3. SLEEVE SEAL SYSTEMS

A. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing elements: Ethylene propylene diene monomer (EPDM) rubber or nitrile butadiene rubber (NBR) interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

2. Pressure plates: Stainless steel.

3. Connecting bolts and nuts: Stainless steel of length required to secure pressure plates to sealing elements.

B. Polyvinyl chloride (PVC) sleeve seal systems are not acceptable.

2.4. GROUT

A. Standard: ASTM C1107, grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink; recommended for interior and exterior applications.

C. Design mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1. GENERAL

A. The contract documents are diagrammatic and are indicative of the work to be performed. It is not intended that they show every pipe, fitting, offset, change in direction, or appurtenance required for a complete installation.

B. All materials used shall be installed in strict accordance with the standards under which the materials are accepted and approved. In the absence of such installation procedures, the manufacturer’s instructions shall be followed. Where the requirements of referenced standards or manufacturer’s installation instructions do not conform to minimum provisions of the North Carolina Plumbing Code, the provisions of the North Carolina Plumbing Code shall apply.

3.2. EXCAVATION, BACKFILLING, COMPACTION, AND RESURFACING

A. General:

1. The contractor shall notify “ONE CALL” prior to any work.

2. The contractor shall perform all excavation, backfilling, compaction, and necessary resurfacing for all piping, equipment, and accessories. Piping installation shall be in accordance with local water, sewer, and gas utility regulations and applicable state and local codes.

3. The contractor shall provide all bracing, sheathing, and shoring necessary to perform and protect their excavations. The contractor shall provide safety rails, lights, signs, etc. as necessary or required for safety, or as required to conform to governing codes and laws.

4. The contractor shall provide, maintain, and operate pumping equipment of sufficient capacity to ensure that all their excavations and trenches are always kept free of water.

5. The contractor shall protect existing structures, utilities, sidewalks, pavements, and other facilities not indicated for removal from damage caused by settlement, lateral movement, undermining, washout, and other hazards from excavation operations.

6. Existing utility lines shown on the contract documents do not indicate the exact location of the lines. The location and depth of all utilities shall be marked and recorded prior to any excavation. Should uncharted or incorrectly charted piping or other utilities be uncovered during excavation, the contractor shall contact the professional immediately for directions before proceeding further with work in this area.

7. All surfaces of streets, walkways, seeded areas, or finished grade areas disturbed by the excavation shall be restored to their original condition and/or as indicated in the contract documents.

8. The presence of explosives on the project site or the use of explosives in the execution of the work under this contract is prohibited.

9. Buried piping shall be supported throughout its entire length.

B. Trenching:

1. All plumbing excavation is unclassified.

2. If trench excavation operations are performed when the atmospheric temperature is less than thirty-five (35) degrees Fahrenheit, the contractor shall provide cold weather protection as required to protect excavated trench bottoms from freezing. Piping shall not be placed in a trench containing water or on a subgrade containing frost.

3. Take up and relay pipe that is not laid true to required alignment or grade. Pipe that has had its joints disturbed after installation shall be taken up and relayed. Deviation from the required lines and grades will not be permitted unless approved by the professional.

4. Trenches shall be dug to uniform width not less than twelve (12) inches and not more than sixteen (16) inches wider than the bell diameter of the piping. Trench sides shall be vertical. Carry depth of trenches for piping as required to establish required slopes and invert elevations. Beyond building perimeter, keep bottom of trenches sufficiently below finished grade to protect against frost. The bottom of trenches shall be accurately graded to provide uniform and smooth flow throughout.

5. Where trenches are excavated such that the bottom of the trench forms the bed for the pipe, solid and continuous load-bearing support shall be provided between joints. Bell holes, hub holes, and coupling holes shall be provided at points where piping is joined. Such pipe shall not be supported on blocks to grade. In instances where the materials manufacturer’s installation instructions are more restrictive that those prescribed by the North Carolina Building Code, the material shall be installed in accordance with the more restrictive requirement.

6. Where trenches are excavated below the installation level of the pipe such that the bottom of the trench does not form the bed for the pipe, the trench shall be backfilled to the installation level of the bottom of the pipe with sand or fine gravel placed in layers not greater than six (6) inches in depth and such backfill shall be compacted after each placement.

7. Where rock is encountered in trenching, the rock shall be removed not less than three (3) inches below the installation level of the bottom of the pipe, and the trench shall be backfilled to the installation level of the bottom of the pipe with sand tamped in place so as to provide uniform load-bearing support for the pipe between joints. The pipe, including joints, shall not rest on rock at any point.

8. If soft materials of poor load-bearing quality are found at the bottom of the trench, stabilization shall be achieved by over-excavating not less than two (2) pipe diameters and backfilling to the installation level of the bottom of the pipe with fine gravel, crushed stone, or a concrete foundation. The concrete foundation shall be bedded with sand tamped into place so as to provide uniform load-bearing support for the pipe between joints.

9. All underground piping shall be laid on first class granular bedding. The bedding shall be a minimum depth of six (6) inches or one-fourth (1/4) the pipe diameter, whichever is greater. The bedding shall provide uniform longitudinal support to the pipe and shall be laid to provide the grade and line as shown on the drawings or as directed by the professional. Hand-tamp the embedment materials under the haunches and around the pipe to the spring-line of the pipe to a compaction density of ninety-five (95) percent. Final embedment for ferrous pipe materials shall extend from the spring-line of the pipe to a depth of six (6) inches minimum above the top of the pipe. Final embedment for nonmetallic pipe shall extend from the spring-line of the pipe to a depth of eighteen (18) inches minimum above the top of the pipe.

C. Backfilling:

1. Backfilling shall not be undertaken until all tests and inspections have been made.

2. When the type of backfill material is not indicated on the plans or is not specified, the excavated material may be used, provided that such material consists of loam, clay, sand, gravel, or other material that is suited for backfilling. From one (1) foot above the top of the pipe to subgrade, material containing stones greater than three (3) inches in their greatest dimension may not be used.

3. Backfill shall be free from discarded construction material and debris. Loose earth free from rocks, broken concrete and frozen chunks shall be placed in the trench in six (6) inch layers and tamped in place until the crown of the pipe is covered by twelve (12) inches of tamped earth. The backfill under and beside the pipe shall be compacted for pipe support. Backfill shall be brought up evenly on both sides of the pipe so that the pipe remains aligned. In instances where the manufacturer's instructions for materials are more restrictive than those prescribed by the North Carolina Plumbing Code, the material shall be installed in accordance with the more restrictive requirement.

4. Backfill trenches to a depth of twelve (12) inches above the top of the outside barrel of the pipe. Continue thereafter with the backfill in twelve (12) inch lifts.

D. Compaction:

1. Compaction shall be accomplished by approved equipment suited to the soil being compacted. Material shall be moistened or aerated as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used.

2. Compacting of this backfill by puddling or jetting will not be permitted. Use mechanical tampers to compact backfill materials in trench refill operations to produce a density of backfill at the bottom of each layer of not less than ninety-five (95) percent of the maximum density obtained at optimum moisture content, in accordance with ASTM D1557, method D and ASTM D1556, sand cone method.

3. The use of specialty equipment for compaction of backfill is prohibited.

E. Resurfacing:

1. All trench backfill shall be brought to subgrade, ready for base material or topsoil. After the initial aggregate backfill layer has been placed, refill the remainder of the trench using backfill materials as follows:

2. Lawns: Successive six (6) inch layers of clean earth backfill material shall be deposited after initial aggregate backfill. This backfill shall consist of excavated material free from large clods of earth and stone. If stones greater than three (3) inches are encountered, remove stones from the site and haul in clean earth backfill. The entire trench shall be uniformly tamped after each successive layer is deposited. Replace topsoil to its original depth and crown to such height as required.

3. Walks and parking areas: Clean earth backfill compacted in six (6) inch layers to a depth of eight (8) inches below the adjacent existing surfaces. Refill the remaining eight (8) inches with compacted stone and replace walk or paving as required.

4. Paved areas: When working within the right-of-way limits of all state highways, backfilling must be in accordance with the requirements of the State Department of Transportation. Trenches located within the areas described above shall be backfilled with aggregate material from the top of the pipe bedding to the bottom elevation of the pavement structure and must be spread and compacted in layers not to exceed four (4) inches when using a mechanical damper. The contractor is to understand that payment for special backfilling material shall not be made unless specifically provided in the form of a proposal.

3.3. ACCESS PANEL INSTALLATION

A. The contractor shall furnish access doors to the general contractor for installation in ceilings, walls, partitions, and floors for access to valves, drains, and other appurtenances which require routine access for proper maintenance, operation, and inspection.

B. Access door locations shall be as determined by field conditions for optimum access to equipment and shall be reviewed by the owner and professional before final installation. Access door locations shall be subject to the following:

1. Bottom of access doors shall not be lower than the top of the partition base, or a minimum of six (6) inches above floor, whichever is greater.

2. Tops and/or sides of access panels shall be a minimum of six (6) inches from the ceiling, any other opening, or from the edge of a wall.

3.4. SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

1. Galvanized steel pipe sleeves: Interior fire-rated partitions; interior non-rated partitions; and concrete slabs above grade.

2. Galvanized steel sheet sleeves: Interior non-rated partitions.

3. Sleeves are not required for core-drilled holes.

B. Install sleeves in suspended concrete floors, concrete roof slabs, and masonry walls as new slabs and walls are constructed.

1. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas two (2) inches above finished floor level.

2. Using grout, seal the space outside of sleeves in slabs and walls.

C. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.

2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe.

3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements of sealants.

D. Fire-resistance rated penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping per the associated UL detail's listing.

3.5. SLEEVE SEAL SYSTEM INSTALLATION

A. Cast iron pipe sleeves with sleeve seals: Exterior masonry walls above and below grade and concrete slabs on grade.

B. Select sleeve size to allow for one- (1) inch annular clear space between piping and sleeve for installing sleeve-seal system.

C. Install sleeve-seal systems in sleeves in exterior masonry walls and slabs-on-grade at service piping entries into building.

D. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.6. INSPECTION AND TESTING

A. General:

1. New plumbing systems and parts of existing systems, which have been altered, extended, or repaired, shall be tested to disclose leaks and defects.

2. The contractor shall notify the professional a minimum of five (5) working days prior to testing to coordinate the testing and inspection procedures.

3. The contractor shall provide all equipment, material, labor, etc. required for testing the plumbing systems.

4. All new, altered, extended, or replaced plumbing systems shall be left uncovered and unconcealed until it has been inspected, tested, and accepted by the professional. Where such work has been covered or concealed before it has been inspected, tested, and accepted, it shall be uncovered by the contractor at their own expense as directed by the professional.

5. If the professional determines that the plumbing systems do not pass the prescribed tests, the contractor shall be required to make the necessary repairs at their own expense. The contractor shall inspect and retest the systems. Repairing, inspection, and testing shall be continued until all systems pass as determined by the professional.

B. Test gauges:

1. Tests requiring a pressure of ten (10) psi or less shall utilize a testing gauge having increments of one-tenth (0.1) psi or less.

2. Tests requiring a pressure of greater than ten (10) psi but less than or equal to one hundred (100) psi shall utilize a testing gauge having increments of one (1) psi or less.

3. Tests requiring a pressure of greater than one hundred (100) psi shall utilize a testing gauge having increments of two (2) psi or less.

END OF SECTION 220100

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SECTION 220105 – PLUMBING SUBMITTAL REQUIREMENTS

PART 1 - GENERAL

1.1. STIPULATIONS

A. General provisions of the contract documents including general and supplementary conditions apply to all work in this division.

B. Failure of the contractor to provide a complete submittal package may result in delay in processing time. All such delays to the project resulting from the contractor's failure to provide submittals in a timely fashion will be the responsibility of the contractor.

1.2. DEFINITIONS

A. Industry standard: Printed copies of the current standards recognized in the industry. Current means the latest issue as of the date of these specifications; within the text of these specifications the date suffix frequently shown with identification numbers has been omitted.

B. Manufacturer's data: Product manufacturer's standard printed information, including promotional brochures, product specifications, installation instructions and diagrams, statements of compliance with standard performance charts or curves, and similar information concerning the standard portions of a manufacturer's products.

C. Manufacturer's warranty: Manufacturer's standard printed commitment about a specific product and normal application, stating that certain acts of restitution will be performed for the purchaser or owner by the manufacturer, if and when the product fails within certain operational conditions and time limits.

D. Operation and maintenance instructions: The written instructions by the manufacturer, fabricator, or installer of equipment or systems, detailing the procedures to be followed by the owner in operation, maintenance, control, and shutdown of each operating item of the equipment or system.

E. Shop drawings: Project shop drawings and other data prepared specifically for fulfillment of the project requirements. Shop drawings include fabrication, layout, setting, installation, coordination, and similar drawings and diagrams, and include performance data associate therewith, including weights, capacities, speeds, outputs, consumption, efficiencies, voltages, amperages, cycles, phases, noise levels, operating ranges, and similar information.

F. Test reports: Specific reports prepared by an independent testing laboratory, showing the results of specified testing on either the material or equipment provided or on identical material or equipment.

1.3. SUBSTITUTIONS

A. Submittals are not opportunities for gaining acceptance of substitutions. Where three (3) or more manufacturers are specified by name or by catalog reference, the contractor shall select for use any of those so specified.

B. Should the contractor desire to substitute another manufacturer's equipment for one specified by name, the contractor shall apply in writing at least ten (10) business days prior to bid date for such permission. The contractor shall provide submittal data for the professional's consideration. No substitution shall be made for any material, article, or process under the contract unless approved by the professional.

C. Any time that is required by the professional for a request to review submittals for substitutions after the award of bids will be billed to the contractor at the professional's published hourly billing rate. The

professional's review time will be billed to the contractor whether the proposed substitution is accepted or rejected.

1.4. SUBMITTAL FORM AND PROCEDURES

A. Submittals shall be assembled as single file electronic submittals. Transmittals shall be included within the file as the first page.

B. Submittals shall be made in separate packages containing all the required documentation indicated in each specification section. Only one (1) submittal package shall be made for each specification section. Partial submissions will not be addressed.

C. Submittals shall be complete and clearly identified and cross-referenced to the appropriate specification section.

D. The data shown on the submittals shall be complete with respect to dimensions, design criteria, materials of construction, and the like to enable the professional to review the information as required.

E. The contractor shall stamp the submittals and verify by signature that the submittals have been checked for compliance with the contract documents and appropriate means have been taken to ensure that the material or equipment will fit into the space available.

F. At the time of each submission, the contractor shall in writing call the professional's attention to any deviations that the submittal may have from the requirements of the contract documents.

G. The submittals shall be clearly marked indicating which specific options are being considered and with all related information.

H. The professional's review of submittals is for general conformance with design concept only. Corrections or comments made on the submittals during review do not relieve the contractor from compliance with requirements of the contract documents.

I. The contractor is responsible for all quantities, dimensions, and coordination of the work of all trades. The contractor is responsible for selecting fabrication processes and techniques of construction and for performing all work in a safe and satisfactory manner.

J. No work requiring a submittal shall be commenced until the submittal has been reviewed by the professional.

K. A copy of each approved submittal shall be kept in good order by the contractor and shall be made available at the site.

1.5. OPERATION AND MAINTENANCE MANUALS

A. Submit after owner acceptance for review by the professional.

B. The contents of the submittal shall be prepared as follows:

1. Table of contents.

2. A directory listing names, addresses, and telephone number of professional, contractor, subcontractors, and equipment suppliers.

3. Project documents and certificates:

a. Certificates of compliance.

b. Photocopies of warranties and bonds.

c. Material safety data sheets (MSDS).

4. Operation and maintenance instructions subdivided by specification section. For each item, identify the following:

a. Significant design criteria.

b. Parts list for each component.

c. Maintenance instructions for equipment and systems.

d. Maintenance instructions for finishes including recommended cleaning methods and materials and operating instructions.

e. Special precautions identifying detrimental agents.

f. Special requirements of other sections of this specification noted to be included in the operation and maintenance manual.

C. Submit copies for review by the owner ten (10) business days prior to owner training.

END OF SECTION 220105

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SECTION 220500 – PLUMBING FIRESTOPPING

PART 1 - GENERAL

1.1. SUMMARY

A. This section includes firestopping requirements and information for Division 22 work.

1.2. DEFINITIONS

A. Firestopping: The use of a material or combination of materials in a fire and/or smoke-rated structure (wall or floor) where it has been breached, so as to restore the integrity of the fire and/or smoke rating on that wall or floor.

B. System: The use of a specific firestop material or combination of materials in conjunction with a specific wall or floor construction type and a specific penetrant(s).

C. Barrier: Any bearing or non-bearing wall or floor that has an hourly fire and smoke rating.

D. Through-Penetration: Any penetration of a fire-rated wall or floor that completely breaches the barrier.

E. Membrane-Penetration: Any penetration in a fire and/or smoke-rated wall or floor/roof-ceiling assembly that breaches only one side of the barrier.

F. Approved Testing Agencies: Not limited to: Underwriters Laboratory (UL), Factory Mutual (FM), and Intertek Group (IG).

1.3. PERFORMANCE REQUIREMENTS

A. Penetrations: Provide through-penetration and membrane-penetration firestop systems that are produced and installed to resist the spread of fire, passage of smoke and other hot gases according to requirements indicated, to restore the original fire and smoke resistance rating of assembly penetrated.

B. Provide and install complete penetration firestopping systems that have been tested and approved by nationally accepted testing agencies per ASTM E814 or UL 1479 fire tests in a configuration that is representative of field conditions.

1. F-Rated Systems: Provide firestop systems with F-ratings indicated and as required by the Building Code.

2. T-Rated Systems: Provide firestop systems with T-ratings and F-ratings indicated and as required by the Building Code.

3. L- Rated Systems: Provide firestop systems with L- ratings less than 5 cfm/sf.

4. W-Rated systems: Provide firestop systems that are resistant to water. For piping penetrations, provide moisture-resistant through-penetration firestop systems.

C. For penetrations involving insulated piping, provide firestop systems not requiring removal of insulation.

D. Firestopping products shall have flame spread ratings less than 25 and smoke-developed ratings less than 450, as determined per ASTM E 84, except firestop products installed in plenum spaces shall have a smoke developed rating less than 50.

E. Engineering Judgment (EJ): Where there is no specific third party tested and classified firestop system available for an installed condition, the Contractor shall obtain from the firestopping material manufacturer an Engineering Judgment (EJ) to be submitted to the Authority Having Jurisdiction (AHJ) and Engineer for approval. The EJ shall follow International Firestop Council (IFC) guidelines.

1.4. SUBMITTALS

A. Product Submittals:

1. Product Data: For each type of firestopping product selected. Manufacturers certification must verify that firestopping materials are free of asbestos, lead and contain volatile organic compounds (VOCs) within limits of the local jurisdiction. Include the following information:

a. Design Listings: Submit system design listings, including illustrations, from a qualified testing and inspecting agency that is applicable to each firestop configuration.

b. Installation Instructions: Submit the manufacturer's installation instruction for each firestop assembly.

c. Engineering Judgements: Where there is no specific third party tested and classified firestop system available for a particular configuration, the Contractor shall obtain from the firestopping material manufacturer an Engineering Judgment (EJ) for submittal.

d. Firestop Schedule: Submit schedule itemizing the following:

1) Manufacturer's product reference numbers and/or drawing numbers.

2) Listing agency's design number.

3) Penetrating Item Description/Limits: Material, size, insulated or uninsulated, and combustibility.

4) Maximum allowable annular space or maximum size opening.

5) Construction type.

6) F rating and, if applicable, T, L, and W ratings.

1.5. QUALITY ASSURANCE

A. Provide firestopping system design listings from FM Global's "Building Materials Approval Guide", Intertek's "Directory of Listed Building Products", or UL's "Fire Resistance Directory" in accordance with the appropriate ASTM Standard(s).

B. Single Source Limitations: Obtain firestop systems for all conditions from a single manufacturer.

1. Materials from different firestop manufacturers shall not be installed in the same firestop system or opening.

C. Firestopping material shall be asbestos and lead free and shall not incorporate nor require the use of hazardous solvents.

D. Firestopping sealants must be flexible, allowing for normal movement.

E. Firestopping materials shall not shrink upon drying as evidenced by cracking or pulling back from contact surfaces such that a void is created.

F. Firestopping materials shall be moisture resistant and may not dissolve in water after curing.

G. Materials used shall be in accordance with the manufacturer's written installation instructions.

H. Installer Qualifications: Installing sub-contractor shall be approved by FM Global according to FM Global 4991, "Approval of Firestop Contractors," or complies with its "Qualified Firestop Contractor Program Requirements."

I. All firestop materials shall be installed prior to expiration date. Store and handle materials per manufacturer's instructions to prevent deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

1.6. COORDINATION

A. Coordinate areas prior to firestopping installation with the Owner, Construction Manager and/or all other Contractors.

B. Coordinate construction of openings and penetrating items to ensure that firestopping assemblies are installed according to specified requirements. Opening shall not exceed maximum restrictions allowable for annular spacing per listing or acceptable Engineering Judgments.

C. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.

D. Do not conceal firestopping installations until the Owner's inspection agency or Authorities Having Jurisdiction have examined each installation.

E. Schedule firestopping after installation of penetrants and joints but prior to concealing or obstructing access to areas requiring firestopping.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Emerson / Nelson Firestop Products.

2. Hilti.

3. 3M, Fire Protection Products Division.

4. Tremco.

2.2. FIRESTOPPING

A. Firestopping products specified in system design listings by approved testing agencies may be used providing they conform to the construction type, penetrant type, annular space requirements and fire rating involved in each separate assembly.

B. Accessories: Provide components for each firestop system that is needed to install fill materials and to comply with "Performance Requirements" Article. Use only components specified by the firestopping manufacturer and by the approved testing agencies for the firestop systems indicated. Accessories include, but are not limited to the following items:

1. Permanent forming/damming/backing materials, including the following:

a. Slag wool fiber insulation.

b. Foams or sealants used to prevent leakage of fill materials in liquid state.

c. Fire-rated form board.

d. Polyethylene/polyurethane backer rod.

e. Rigid polystyrene board.

2. Temporary forming materials.

3. Substrate primers.

4. Steel sleeves.

C. All firestopping products and systems shall be designed and installed so that the basic sealing system will allow the full restoration of the thermal and fire resistance properties of the barrier being penetrated with minimal repair if penetrants are subsequently removed.

D. Mold Resistance: Provide penetration firestopping with mold and mildew resistance rating of zero (0) as determined by ASTM G21.

PART 3 - EXECUTION

3.1. GENERAL REQUIREMENTS

A. Provide firestop systems consisting of a material, or combination of materials installed to retain the integrity of fire resistance rated construction by maintaining an effective barrier against the spread of flame, smoke and/or hot gases through penetrations, fire resistive joints, and perimeter openings in accordance with the requirements of the Building Code for this project.

B. Firestop systems shall be used in locations including, but not limited to, the following:

1. Penetrations through fire resistance rated floor and roof assemblies including both empty openings and openings containing penetrants.

2. Penetrations through fire resistance rated wall assemblies including both empty openings and openings containing penetrants.

3. Membrane penetrations in fire resistance rated wall assemblies where items penetrate one side of the barrier.

3.2. EXAMINATION

A. Examine substrates and conditions for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance.

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

C. Verify that all pipes, conduits, cables, and/or other items which penetrate fire-rated construction have been permanently installed prior to installation of firestops.

3.3. PREPARATION

A. Surface Cleaning: Clean out openings immediately before installing firestop systems to comply with written recommendations of firestopping manufacturer and the following requirements:

B. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of firestop systems.

C. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with firestop systems. Remove loose particles remaining from cleaning operation.

D. For those products requiring mixing before application, comply with firestopping manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

3.4. INSTALLATION

A. General: Install firestop systems to comply with firestopping manufacturer's written installation instructions and published drawings for products and applications indicated.

B. Apply firestopping in accordance with approved testing agencies listed system designs or manufacturer's EJ per the manufacturer's installation instructions.

C. Verify that environmental conditions are safe and suitable for installation of firestop products. Application areas shall be protected from weather, dry and within recommended temperature and humidity ranges of materials being installed.

D. Install forming/damming/backing materials and other accessories required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire resistance ratings required.

E. Install metal framing, mechanical attachments, safing materials and firestop materials as applicable within the system design.

F. Install fill materials for firestop systems by proven techniques to produce the following results:

1. Fill voids, joints and cavities formed by openings, forming materials, accessories, and penetrating items as required to achieve fire-resistance ratings indicated.

2. Apply materials so they fully contact and adhere to substrates formed by openings and penetrating items.

3. For fill materials that will remain exposed after completing work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

4. Tool non-sag firestop materials after their application and prior to the time skinning begins. Use tooling agents approved by the firestopping manufacturer.

G. Label penetration ratings and UL detail numbers on wall surfaces directly adjacent to the penetrations. This information shall be readily visible in non-occupied spaces, within chases and above ceilings.

1. Comply with Section 220553 for identification and labeling requirements.

3.5. FIELD QUALITY CONTROL

A. Inspecting Agency: Authorities Having Jurisdiction, the Owner, or Owner's Representative shall be allowed to perform random destructive testing during inspection of firestop systems to verify compliance per listings or manufacturer's installation instructions. All areas of work must be accessible until inspection by the applicable Authorities Having Jurisdiction and inspection agencies. The contractor shall be responsible to repair all tested assemblies with no cost to the owner.

B. Proceed with enclosing firestop systems with other construction only after inspections are complete.

C. Where deficiencies are found as determined by the Engineer, remove and replace firestop systems so they comply with requirements.

3.6. CLEANING AND PROTECTION

A. Clean off excess fill materials adjacent to openings, as work progresses by methods and with cleaning materials that are approved in writing by firestopping manufacturer(s) and that do not damage materials in which openings occur. Leave finished work in neat, clean condition with no evidence of spillovers or damage to adjacent surfaces.

B. Provide final protection and maintain conditions during and after installation that ensure firestop systems are without damage or deterioration at time of Owner Acceptance. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated firestop systems immediately and install new materials to produce firestop systems complying with specified requirements.

END OF SECTION 220500

SECTION 220519 – PLUMBING INSTRUMENTS AND GAGES

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes instruments and gages for plumbing systems.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1. Product Certificates: For each type of instrument and gage from manufacturer.

B. Closeout Submittals:

1. Operation and Maintenance Data: For instruments and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1. THERMOMETERS

A. Standard: ASME B40.200.

B. Liquid-in-Glass Thermometers: 9-inch cast aluminum case with adjustable angle; glass tube with magnifying lens and blue or red organic liquid; non-reflective aluminum with permanently etched scale markings graduated in deg F and deg C; glass window; aluminum stem of length suitable for application for Thermowell installation; 1-1/4 inch connector with ASME B1.1 screw threads; and accuracy to plus or minus 1 percent of scale range.

C. Light-Activated Thermometers: 6-inch metal or plastic case with adjustable angle; digital display with scale graduated in deg F and deg C; aluminum stem of length suitable for application for Thermowell installation; 1-1/4 inch connector with ASME B1.1 screw threads; and accuracy to plus or minus 1 deg C.

D. Thermometer Scale Ranges for Piping Systems:

1. Cold Water: 0 to 100 deg F.

2. Hot Water: 0 to 250 deg F.

E. Thermometer stems shall be of length to match thermowell insertion length.

2.2. THERMOWELLS

A. Standard: ASME B40.200.

B. Thermowells: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.

1. Material for Use with Copper Tubing: Copper-nickel (90-10) or copper-nickel (70-30).
2. Type: Stepped shank unless straight or tapered shank is indicated.
3. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
4. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
5. Bore: Diameter required to match thermometer bulb or stem.
6. Insertion Length: Length required to match thermometer bulb or stem.
7. Lagging Extension: Include on thermowells for insulated piping and tubing.
8. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

C. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.3. PRESSURE GAGES

A. Standard: ASME B40.100.

B. Dial-Type Pressure Gages: Oil-filled, cast aluminum case with 4-1/2 inch nominal diameter; non-reflective aluminum dial with permanently etched scale markings graduated in psi and kPa; bourbon tube pressure element assembly; brass pressure connection with NPS 1/4 or 1/2 inch ASME B1.20 pipe threads and bottom-outlet; mechanical movement with link pressure element and connection to pointer; glass window; stainless steel ring; dark colored metal pointer; and accuracy to plus or minus 1 percent of scale range.

C. Scale Ranges for Piping Systems:

1. Cold and Hot Water: 0 to 100 psi.

2.4. GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and surge-dampening device. Include extension for use on insulated piping.

B. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.5. TEST PLUGS

A. Test Plug: Test-station fitting made for insertion into piping tee fitting; brass or stainless steel body including extended stem when used on insulated piping; core inserts and gasketed and threaded cap; ASME B1.20.1 pipe threads; chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber core inserts; rated for a minimum of 500 psig at 200 deg F.

PART 3 - EXECUTION

3.1. INSTALLATION

A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

H. Install valve and snubber in piping for each pressure gage for fluids.

I. Install test plugs in piping tees.

J. Install flow indicators in piping systems in accessible positions for easy viewing.

K. Install permanent indicators on walls or brackets in accessible and readable positions.

L. Install connection fittings in accessible locations for attachment to portable indicators.

M. Install thermometers in the inlet and outlet piping of each:

1. Water heater.

N. Install pressure gages in the inlet and outlet piping of each:

1. Plumbing pump.
2. Pressure-reducing valve.
3. Water heater.

3.2. ADJUSTING

A. Adjust faces of instruments and gages to proper angle for best visibility.

END OF SECTION 220519

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SECTION 220523 – PLUMBING PIPING VALVES

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes general duty valves for plumbing piping systems such as ball, check, and globe valves and associated accessories.

1.2. SUBMITTALS

A. Product Submittals: For each type of valve indicated.

1.3. QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
2. ASME B31.1 for power piping valves.
3. ASME B31.9 for building services piping valves.

1.4. DELIVERY, STORAGE AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.

2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use hand wheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide product by one of the following:

1. Apollo Valves / Conbraco.
2. Milwaukee Valve / Hammond Valve.
3. NIBCO.
4. Watts.

2.2. GENERAL REQUIREMENTS

A. Refer to plumbing valve schedule articles for applications of valves.

B. NSF Compliance: NSF 61 Annex G and NSF 372 for valve materials for potable water service.

C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15-percent zinc are not permitted.

D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream piping unless otherwise indicated.

F. Valve Actuator Types:

1. Hand Wheel: For valves other than quarter-turn types.
2. Hand Lever: For quarter-turn valves 4-inches NPS and smaller except plug valves.

G. Valves in Insulated Piping: Provide 2-inch stem extensions.

1. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.

H. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Threaded: With threads according to ASME B1.20.1.

I. Valve Bypass and Drain Connections: MSS SP-45.

2.3. BALL VALVES

A. Ball Valves, 2-inches NPS and smaller: Two-piece, full-port, quarter-turn, forged brass or bronze ball valves with stainless steel trim, PTFE seats, adjustable stem packing and anti-blowout stem, rated for 600 psig CWP (cold working pressure). Valves shall comply with MSS SP-110. Valves shall have threaded ends.

B. Ball Valves, 2 1/2-inches NPS and larger: Split-body, full-port, ASTM A126 iron body with stainless steel trim, PTFE seats, rated for 200 psig CWP (cold working pressure). Valves shall comply with MSS SP-72. Valves shall have flanged ends.

2.4. CHECK VALVES

A. Swing Check Valves, 2-inches NPS and smaller: Y-pattern bronze swing check valves for horizontal flow with bronze disc and Class 125 rated for 200 psig CWP (cold working pressure). Valves shall comply with MSS SP-80 Type 3. Valves shall have threaded ends.

2.5. GLOBE VALVES

A. Globe Valves, 2-inches NPS and smaller: Bronze body with integral seat and union-ring bonnet globe valves with bronze trim, PTFE or TFE seats and asbestos-free packing, Class 125 rated for 200 psig CWP (cold working pressure). Hand-wheels shall be malleable or ductile iron. Valves shall comply with MSS SP-80. Valves shall have threaded ends.

2.6. MANUAL CALIBRATED BALANCING VALVES

A. Manual Calibrated Balancing Valves: Armstrong CBV Series, Bell & Gossett Circuit Setter Plus Series, Griswold QuickSet Series or TACO Accu-Flo Series.

1. Flow Verification: Provide a differential pressure versus flow calibration charts for use by the Engineer and TAB sub-contractor.

2.7. AUTOMATIC BALANCING VALVES

A. Automatic Balancing Valves: Valves shall maintain constant flow within 5 percent, plus or minus, over system pressure fluctuations.

1. Flow Verification: Provide electronic differential pressure meter that can read differential pressure including flowmeter, probes, hoses, flow charts and carrying case.

2. Cartridge Exchange: For up to 1 year from acceptance of the final TAB Report, up to 10% of cartridges in the project may be replaced as needed for any reason as determined by the Engineer.

B. Automatic Balancing Valves, 2-inches NPS and smaller: Combination automatic balancing valve and isolation valve with Y-pattern brass body; removable stainless steel flow cartridge; stainless steel spring; EPDM O-ring; two pressure and temperature ports; and rated for 175 psig CWP (cold working pressure). Isolation valve shall be quarter-turn ball valve with brass or stainless steel ball. Flow cartridge shall be stamped with flow rate. Flow Design (FDI) AutoFlow AC Series, Griswold Isolator R Series, Nexus Valve UltraMatic UM Series, or Victaulic 76 Series.

PART 3 - EXECUTION

3.1. EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2. VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Install valves in branch lines to isolate sections of the piping system.

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

D. Install valves in horizontal piping with stem at or above center of pipe. Valves with stems below center of piping are not acceptable.

E. Install valves in position to allow full stem movement.

F. Valves shall be equipped with stem extensions for all applications where the piping will be insulated.

G. Install check valves at each pump discharge and elsewhere as required to control flow direction.

H. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.

3.3. ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4. GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. Piping systems shall use the following valve types unless otherwise indicated on the drawings or in other Division 22 sections:

1. Shutoff: Ball.

2. Throttling: Globe or ball.

3. Pump Discharge Check Valves: For 2-inches NPS and smaller, swing check valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

END OF SECTION 220523

SECTION 220529 – PLUMBING HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes pipe hangers and hanger shields, metal framing systems, fastener systems, pipe-stands, and equipment supports.

1.2. PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.3. SUBMITTALS

A. Qualification Submittals: Welding certificates.

B. Product Submittals: For each type of product indicated.

1.4. QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1. METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports: MSS SP-58, Types 1 through 58, factory-fabricated components. Hangers shall be galvanized. Padded hangers shall be fiberglass pad or cushion to support bearing surface of piping. Hanger rods shall be continuously threaded with nuts and washers made of carbon steel.

B. Copper Pipe Hangers: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components. Hanger rods shall be continuously threaded with nuts and washers made of stainless steel.

2.2. TRAPEZE PIPE HANGERS

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

2.3. METAL FRAMING SYSTEMS

A. Description: Shop or field-fabricated pipe-support assembly for supporting multiple parallel pipes. Channels shall be continuous slotted steel with in-turned lips. Channel nuts shall be designed to fit into channel slot and when tightened to prevent slipping. Hanger rods shall be continuously threaded with nuts and washers made of carbon steel.

2.4. THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength. For cold piping systems, include vapor barrier.

B. Insert and shield shall cover the entire pipe circumference for trapeze of clamped systems and cover the lower 180-degrees of pipe circumference for clevis or band hangers.

C. Insert Length: Extend two (2) inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5. 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. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened Portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6. EQUIPMENT SUPPORTS

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

2.7. MISCELLANEOUS MATERIALS

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

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

1. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1. HANGER AND SUPPORT INSTALLATION

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

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

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

D. Fastener System Installation:

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

2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

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

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

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

H. Install lateral bracing with pipe hangers and supports to prevent swaying as required by the North Carolina Plumbing Code.

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

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

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

L. Insulated Piping:

1. Attach clamps and spacers to piping. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping. Clamps may project through the insulation of hot piping systems. Use thermal hanger shield inserts with clamp sized to match outside diameter of insert for cold piping systems.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

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

a. Less than 4-inches NPS: 12-inches long and 0.060-inch thick.

b. 4 to 6-inches NPS: 18-inches long and 0.060-inch thick.

c. 8 to 14-inches NPS: 24-inches long and 0.075-inch thick.

d. 16 to 24-inches NPS: 24-inches long and 0.105-inch thick.

5. Pipes 8-inches NPS and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.

6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2. EQUIPMENT SUPPORTS

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

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

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

3.3. METAL FABRICATIONS

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

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

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

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.

4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4. ADJUSTING

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

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

3.5. PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6. HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

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

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

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

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

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

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

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

I. Horizontal-Piping Hangers and Supports:

1. Adjustable Steel Clevis Hangers (MSS Type 1).

2. Split-Ring Hangers (MSS Type 69): Piping 2-inches NPS and smaller.

3. Copper Pipe Hangers: For copper piping.

J. Trapeze Pipe-Hangers: Trapeze hangers shall be welded carbon steel pre-formed structural members suspended by threaded rods. Comply with MSS SP-69. Each pipe shall be individually supported.

1. Adjustable Pipe Saddles (MSS Type 38).

2. Copper Pipe Saddles: For copper piping.

K. Vertical-Piping Clamps:

1. Riser Clamps (MSS Type 8).

L. Building Attachments: Install MSS compliant devices for all building attachments. Install them per manufacturer's instructions.

M. Saddles and Shields:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.

2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.

3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

N. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

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

3.7. PIPE HANGER INSTALLATION

A. Steel Piping: Install hangers for steel piping with the following minimum rod sizes and maximum spacing:

HORIZONTAL PIPE HANGER SCHEDULE (STEEL/CAST-IRON)						
SYSTEM	WATER		FUEL GAS		WASTE AND VENT	
MATERIAL	SCHEDULE 40 STEEL		SCHEDULE 40 STEEL		CAST-IRON SOIL DWV	
PIPE DIAMETER (INCHES)	MINIMUM HANGER ROD DIA. (INCHES)	MAXIMUM HANGER SPACING (FEET)	MINIMUM HANGER ROD DIA. (INCHES)	MAXIMUM HANGER SPACING (FEET)	MINIMUM HANGER ROD DIA. (INCHES)	MAXIMUM HANGER SPACING (FEET)
1/2	3/8	6	3/8	6		
3/4	3/8	6	3/8	8		
1	3/8	6	3/8	8		
1 1/4	3/8	6	3/8	8		
1 1/2	3/8	8	3/8	8	3/8	5
2	3/8	10	3/8	8	3/8	5
2 1/2	3/8	10	1/2	10		
3	1/2	12	1/2	10	1/2	5
4	5/8	12	5/8	10	5/8	5
5	5/8	12	5/8	10	5/8	5
6	3/4	12	5/8	10	3/4	5
8	3/4	12			3/4	5
10	7/8	12			7/8	5
12	7/8	12			7/8	5
14	1	12				
16	1	12				
18	1 1/4	12				
20	1 1/4	12				
24	1 1/2	12				

B. Copper Piping: Install hangers for drawn-temper copper piping with the following minimum rod sizes and maximum spacing:

HORIZONTAL PIPE HANGER SCHEDULE (COPPER)						
SYSTEM	WATER		FUEL GAS		MGAS / VACUUM	
MATERIAL	DRAWN-TUBE COPPER		DRAWN-TUBE COPPER		DRAWN-TUBE COPPER	
PIPE DIAMETER (INCHES)	MINIMUM HANGER ROD DIA. (INCHES)	MAXIMUM HANGER SPACING (FEET)	MINIMUM HANGER ROD DIA. (INCHES)	MAXIMUM HANGER SPACING (FEET)	MINIMUM HANGER ROD DIA. (INCHES)	MAXIMUM HANGER SPACING (FEET)
1/2	3/8	5	3/8	4	3/8	6
3/4	3/8	5	3/8	6	3/8	6
1	3/8	5	3/8	6	3/8	8
1 1/4	3/8	5	3/8	8	3/8	8
1 1/2	3/8	8	3/8	8	3/8	10
2	3/8	8	3/8	8	3/8	10
2 1/2	1/2	8			1/2	10
3	1/2	10			1/2	10
4	5/8	10			1/2	10
5					1/2	10
6					5/8	10
8					3/4	10

C. Support vertical runs at roof, at each floor, and at 8-foot intervals between floors.

END OF SECTION 220529

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SECTION 220553 – PLUMBING SYSTEMS IDENTIFICATION

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes equipment, pipe, and duct labels and tags.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1. Product Data: For each type of product indicated.

2. Samples: For color, letter style, and graphic representation required for each identification material and device.

B. Closeout Submittals:

1. Valve Schedules: For each piping system to include in maintenance manuals.

1.3. COORDINATION

A. Coordinate the identification requirements with the Owner’s up-to-date standards prior to purchasing materials.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with locations of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1. EQUIPMENT LABELS

A. Plastic Labels for Equipment: 1/8-inch multilayer, multicolor, plastic labels for mechanical engraving suitable for temperatures up to 160 deg F with pre-drilled holes for stainless steel rivets or self-tapping screws. Labels shall be minimum 2-1/2 inches wide and 3/4-inch tall with 3/8-inch white letters on black background.

1. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's drawing designation or unique equipment number.

2.2. WARNING SIGNS AND LABELS

A. Warning Signs and Labels: 1/8-inch multilayer, multicolor, plastic labels for mechanical engraving suitable for temperatures up to 160 deg F with pre-drilled holes for stainless steel rivets or self-tapping screws. Labels shall be minimum 2-1/2 inches wide and 3/4-inch tall with 3/8-inch letters.

1. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3. PIPE LABELS

A. Pipe Labels: Pre-printed, color-coded, self-adhesive vinyl labels with lettering and flow direction arrows. They shall have minimum 1-1/2-inch tall block lettering. The labels shall be suitable for temperatures up to 160 °F and compatible with each substrate material.

2.4. VALVE TAGS

A. Valve Tags: 0.032-inch thick brass or 0.025-inch thick stainless steel, stamped or engraved, with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers with pre-drilled or stamped holes for beaded chain or S-hook attachment hardware.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.5. CEILING TAGS

A. Ceiling Tags: 0.030-inch thick and 3/4 to 7/8-inch diameter rigid vinyl, self-adhesive, plastic tags with pre-printed, minimum 1/8-inch tall block-letter text indicating the equipment, valve or accessory tag and number designations.

2.6. WARNING TAGS

A. Warning Tags: 5-1/4 inches wide and 3-inches tall, pre-printed or partially pre-printed, accident-prevention tags, of plasticized card stock with matte finish suitable for writing, fastened with reinforced grommet and wire. Tags shall have letters with large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

PART 3 - EXECUTION

3.1. PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulates.

3.2. PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.

2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.

3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.

4. At access doors, manholes, and similar access points that permit view of concealed piping.

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

6. Spaced at maximum intervals of 25 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.

7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

3.3. EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of plumbing equipment.

B. Central plumbing system equipment labels shall include capacity and design information. Submit proposed label information for Engineer approval. The following are example:

1. Water Heater:

WATER HEATER WH-1
INSTALLED: JUNE 2030
CAPACITY: 100 GALLONS
RECOVERY: 20 GPH
OUTPUT: 800 MBH
INPUT: 1000 MBH

C. Locate equipment labels where accessible and visible.

D. Equipment Color Schedule: Insulation color and label scheme shall match the associated piping system.

3.4. VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

3.5. CEILING TAG INSTALLATION

A. Install ceiling tags on lay-in grid and access doors below equipment, valves and accessories above finished ceilings. Center tags on grid members and doors.

3.6. WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

3.7. RATED PENETRATION INSTALLATION

A. Stencil penetration ratings and UL detail numbers on wall surfaces directly adjacent to the penetrations. UL detail number shall match the material used. This information shall be readily visible in non-occupied spaces, within chases and above ceilings. The following is an example:

2-HR RATED FIRE BARRIER
UL DETAIL SYSTEM NO. ABC-0000

3.8. SYSTEM IDENTIFICATION SCHEDULE

A. Install equipment and piping identification materials with the color and abbreviations that match the Owner's standard practice. Refer to System Identification Schedule below.

SYSTEM IDENTIFICATION SCHEDULE			
PIPING SYSTEMS	ABBREV.	BACKGROUND	LETTERING
DOMESTIC WATER	DCW/DHW/DHWR	GREEN	WHITE
NON-POTABLE WATER	NPW	LIGHT GRAY	WHITE
REAGENT WATER	DI/RO/DISTILLED	BROWN	WHITE
CONDENSATE DRAIN	CD	WHITE	BLACK
STORM DRAINAGE	STORM	BLACK	WHITE
SANITARY WASTE AND VENT	WASTE/VENT	BLACK	WHITE
ACID WASTE AND VENT	ACID WASTE/VENT	SAFETY YELLOW	BLACK
COMPRESSED AIR	AIR	LIGHT ORANGE	BLACK
INSTRUMENT AIR	CONFORM TO NFPA 99, TABLE 5.1.11		
MEDICAL-GRADE COMPRESSED AIR	CONFORM TO NFPA 99, TABLE 5.1.11		
VACUUM	CONFORM TO NFPA 99, TABLE 5.1.11		
MEDICAL GASES	CONFORM TO NFPA 99, TABLE 5.1.11		
FIRE PROTECTION	FIRE	BRIGHT RED	WHITE
NATURAL GAS	NG	YELLOW	BLACK
PROPANE GAS	LPG	YELLOW	BLACK
FUEL OIL	FO	YELLOW	BLACK
DIESEL FUEL	DIESEL	YELLOW	BLACK
OTHERS	SEE PLANS	WHITE	BLACK
VALVE TAGS		BRASS	BLACK
EQUIPMENT AND DUCT SYSTEMS	ABBREV.	BACKGROUND	LETTERING
WARNING SIGNS	SEE PLANS	SAFETY YELLOW	BLACK
CEILING GRID MARKERS	SEE PLANS	CLEAR	BLACK
EQUIPMENT TAGS	SEE PLANS	BLACK	WHITE

NOTE: PROVIDE FLOW ARROWS ON ALL PIPE MARKERS.

END OF SECTION 220553

SECTION 220719 – PLUMBING INSULATION

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes insulation of plumbing piping systems.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

1.3. QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Indoors installed in air plenums: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2. Indoors not installed in air plenums: Flame-spread index of 25 or less, and smoke-developed index of 450 or less.

1.4. DELIVERY, STORAGE AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

B. Storage: Insulation material shall be stored in a dry location sealed in plastic to prevent moisture infiltration. Insulation material, installed or not, that becomes wet, dirty, etc. shall be removed and replaced. “Dried” or “cleaned” insulation materials shall not be used.

1.5. COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields.

B. Coordinate clearance requirements with piping installer for piping insulation application. Before preparing piping shop drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.6. SCHEDULING

A. Schedule insulation installation after pressure testing systems. Insulation applied prior to satisfactory test results shall be removed and replaced.

PART 2 - PRODUCTS

2.1. INSULATION MATERIALS

A. General: Comply with requirements in Piping Insulation Schedule and Field-Applied Jacket Schedule articles for where insulating materials shall be applied.

1. Products shall not contain asbestos, formaldehyde, lead, mercury, or mercury compounds.

2. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

3. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

4. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

5. Fitting Covers: Field apply insulation to cover valves, elbows, tees, and flanges.

B. Mineral-Fiber, Preformed Pipe Insulation:

1. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL.

2. Type II, 1200 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, with factory-applied ASJ-SSL.

3. Thermal conductivity (k-value) maximum value of 0.34 BTU in /(hr sqft deg F) for fluid temperatures above 350 deg F; 0.32 for fluids 350 deg F and lower; 0.30 for fluids 250 deg F and lower; 0.29 for fluids 200 deg F and lower; 0.27 for fluids 60 deg F and lower; and 0.26 for fluids 40 deg F and lower.

C. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

1. Thermal conductivity (k-value) maximum value of 0.15 BTU in /(hr sqft deg F) for fluid temperatures 60 deg F and lower

2.2. FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets for various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White outward facing, bleached kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing.

2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

2.3. FIELD-APPLIED JACKETS

A. Insulation system schedules indicate field-applied jackets for various applications. When field-applied jackets are indicated, comply with the following:

1. PVC Jacket: High-impact resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C, 20-mils thick.

a. Adhesive: As recommended by jacket material manufacturer.

b. Color: Comply with Section 220553.

c. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

1) Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

2. Woven Glass-Fiber Fabric Jacket: Comply with MIL-C-20079H, Type I, plain weave, and pre-sized a minimum of 8 oz./sq. yd.

2.4. INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

2.5. PIPING INSULATION INSTALLATION MATERIALS

A. General: Adhesives, mastics and sealants shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated. Indoor applications shall comply with low-VOC requirements of Section 220100.

B. Adhesives:

1. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

2. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

3. ASJ Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

4. PVC Jacket Adhesive: Compatible with PVC jacket.

C. Mastics: Comply with MIL-PRF-19565C, Type II.

1. Vapor-Barrier Mastic: Water based, white, suitable for indoor use on below-ambient services with water-vapor permeance of 0.013 perm at 43-mil dry film thickness per ASTM E 96/E 96M, Procedure B; service temperature range of minus 20 to plus 180 deg F; and solids content of 58 percent by volume and 70 percent by weight per ASTM D 1644.

2. Breather Mastic: Water based; white, suitable for indoor and outdoor use on above-ambient services with service temperature range of minus 20 to plus 180 deg F; water-vapor permeance of 1.8 perms at 0.0625-inch dry film thickness per ASTM F 1249; and solids content of 60 percent by volume and 66 percent by weight.

D. Sealants:

1. Joint Sealants: Permanently flexible, white or gray, elastomeric sealant with service temperature range of minus100 to plus 300 deg F.

2. ASJ Flashing Sealants and Vinyl and PVC Jacket Flashing Sealants: Fire and water-resistant, white, flexible, elastomeric sealant with service temperature range of minus 40 to plus 250 deg F.

E. Tapes:

1. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

2. PVC Tape: Vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

PART 3 - GENERAL

3.1. INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:

1. Mineral-Fiber: 1/2-inch thick for 1/2 to 1-1/4-inches NPS and 1-inches thick for 1-1/2-inches and larger.

B. Domestic Hot and Recirculated Water:

1. Mineral-Fiber: 1/2-inch thick for 1/2 to 1-1/4-inches NPS and 1-inches thick for 1-1/2-inches and larger.

C. Storm Water and Overflow: Insulate all horizontal piping and the first 20 feet of piping downstream of each roof drain. Insulate roof and overflow drain bodies with pre-formed insulation of the same type.

1. Mineral-Fiber: 1-inch thick for all pipe sizes.

D. Floor Drains, Traps and Sanitary Drain Piping: Insulate within 10 feet of all drains receiving condensate and equipment drain water below 60 deg F.

1. Mineral-Fiber: 1-inch thick for all pipe sizes.

E. Exposed Domestic Hot Water, Domestic Cold Water, and Sanitary Drains Piping and Stops for Plumbing Fixtures for People with Disabilities:

1. Molded Vinyl: 1/8-inch thick for all pipe sizes, ADA compliant, and anti-microbial surface compliant with ASTM G21. P-traps shall have vent at bottom.

3.2. FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Indoor Piping Jacket:

1. Concealed Piping: None.

2. Exposed Piping:

a. Up to six (6) feet above floor and where exposed in food preparation and food service areas: 20 mils thick PVC.

b. Greater than six (6) feet above floor: woven-glass fiber fabric.

3.3. EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.

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

3.4. PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.5. GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches on center.

3. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

4. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least four (4) inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

O. For above-ambient services, do not install insulation to the following:

1. Testing agency labels and stamps.

2. Nameplates and data plates.

3. Manholes.

4. Handholes.

5. Cleanouts.

P. Piping insulation shall be continuous and not interrupted by hangers and supports. Hangers shall include factory-fabricated galvanized steel insulation shields that comply with MSS-58. Insulation installed that encapsulates any part of the hanger shall be removed and reinstalled.

3.6. PENETRATIONS

A. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

B. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 220500 for firestopping and fire-resistive joint sealers.

C. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.

2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 220500.

3.7. PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.

2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece

and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations necessary to access components. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with

tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.8. INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.

4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.

2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.

2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3. Install insulation to flanges as specified for flange insulation application.

4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.9. INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.

2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.

3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at six (6) inches on center.

4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.

4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.

2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.

2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.

3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

4. Install insulation to flanges as specified for flange insulation application.

3.10. FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.

2. Embed glass cloth between two 0.062-inch thick coats of lagging adhesive.

3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

3.11. FINISHES

A. Paint pipe insulation with ASJ, glass-cloth, or other paintable jacket material. Color shall be selected by the Owner. Refer to Section 220553 – Plumbing Piping and Equipment Identification.

1. Prime with 2 coats of water-based white acrylic primer paint designed for use with associated jacket material.

2. Finish with 2 coats of flat latex paint with fungicidal agent additive to render fabric mildew proof.

3. Do not field paint aluminum or stainless-steel jackets.

B. Apply paint and primer at the recommended spreading rate and film thickness as recommended by the paint manufacturer.

C. Apply paint and primer within the environmental conditions recommended by the paint manufacturer but not less than 55F; not more than 90F; and not more than 70% RH.

D. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

END OF SECTION 220719

SECTION 221116 – DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes pipe and fitting materials and joining methods for domestic water piping.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1. Pipe and fitting manufacturing source list confirming the materials will be products of the United States of America.

B. Construction Submittals: System purging and disinfecting reports.

C. Closeout Submittals: Final disinfecting report.

1.3. QUALITY ASSURANCE

A. All piping and fittings shall be products of the United States of America. All other piping and fittings will be removed from the project at the contractor's expense.

1. This requirement does not apply to piping that is internal to and factory-fabricated and installed in unitary equipment. The requirement does apply to all field-installed piping and skid-mounted assemblies with factory-fabricated and installed piping.

PART 2 - PRODUCTS

2.1. PERFORMANCE REQUIREMENTS

A. Domestic water piping and components shall be capable of withstanding 80 psig at 75 °F. Piping systems shall be pressure tested, leak tested, flushed, and disinfected:

2.2. COPPER TUBE AND FITTINGS

A. Drawn-Temper ("Hard") Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper ("Soft") Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Wrought-Copper Fittings and Unions: ASME B16.22.

E. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

F. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

G. Copper Unions: MSS SP-123, cast-copper alloy with hexagonal-stock body, ball-and-socket metal-to-metal seating surfaces, and solder joint or threaded ends.

2.3. JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for domestic water piping systems.

1. AWWA C110/A21.10, rubber, flat face, 1/8-inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.

2. Full-face or ring type unless otherwise indicated.

B. Flange Bolts and Nuts: ASME B18.2.1, Grade B7, carbon steel, unless otherwise indicated.

C. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

2.4. DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating non-conductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions, 2-inches NPS and smaller: Factory-fabricated ASSE 1079 rated for 150 psig at 180 °F with solder-joint copper alloy and threaded ferrous end connections.

C. Dielectric Nipples, 4-inches NPS and smaller: Factory-fabricated IAPMO PS 66 electro-plated steel nipple complying with ASTM F1545, inert and non-corrosive propylene, rated for 300 psig at 225 °F, and threaded end connections

PART 3 - EXECUTION

3.1. PIPING APPLICATIONS

A. Domestic Water Piping, Above Ground:

1. Copper Piping: Type L, drawn-temper (“hard”) copper tubing, wrought-copper fittings, and soldered joints.

B. Domestic Water Piping, Below Slab:

1. Copper Piping: Type K, annealed-temper (“soft”) copper tubing, wrought-copper fittings, and soldered joints. No joints shall be located below grade.

3.2. PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install underground copper tube in PE encasement according to ASTM A 674 or AWWA C105/A21.5.

D. Install shutoff valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 220519 and with requirements for drain valves and strainers in Section 221119.

E. Install shutoff valve immediately upstream of each dielectric fitting.

F. Install domestic water piping level and plumb.

G. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

H. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

I. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

J. Install piping to permit valve servicing.

K. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

L. Install piping free of sags and bends.

M. Install fittings for changes in direction and branch connections.

N. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

O. Install piping to permit valve servicing. All valves shall be installed within eighteen (18) of the ceiling above which they are installed.

P. Install piping to allow application of insulation.

Q. Select system components with pressure rating equal to or greater than system operating pressure.

R. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

S. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

T. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 220519.

U. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 221123.

V. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 220519.

W. Install sleeves for piping penetrations of walls, ceilings, and floors

X. Install sleeve seals for piping penetrations of concrete walls and slabs.

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.3. DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

1. Piping 4-inches NPS and Smaller: Dielectric nipples or unions.

3.4. HANGERS AND SUPPORTS

A. Comply with requirements in Section 220529 for hanger, support, anchor devices, and maximum spacings.

1. Straight Lengths: Adjustable clevis hangers.

3.5. PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.

D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

E. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

3.6. CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve.

3.7. IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 220553.

B. Label pressure piping with system operating pressure.

3.8. FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Piping Inspections:

a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.

b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.

2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.

c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections, and arrange for reinspection.

2. Piping Tests:

a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.

b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.

c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.

d. Cap and subject piping to static water pressure of 100 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.

f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.9. ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.

2. Open shutoff valves to fully open position.

3. Open throttling valves to proper setting.

4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.

a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.

b. Adjust calibrated balancing valves to flows indicated.

5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.

6. Remove and clean strainer screens. Close drain valves and replace drain plugs.

7. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.10. CLEANING

A. Clean and disinfect potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.

2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:

   a. Flush piping system with clean, potable water until dirty water does not appear at outlets.

   b. Fill and isolate system according to either of the following:

      1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.

      2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.

   c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.

   d. Repeat procedures if biological examination shows contamination.

B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.11. PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Fitting Option: Brazed joints may be used on aboveground copper tubing.

D. Under-building-slab, domestic water, building-service piping, shall be the following:

1. Soft copper tube, ASTM B88, Type K wrought-copper, solder-joint fittings; and brazed joints.

E. Aboveground domestic water piping, shall be the following:

1. Hard copper tube, ASTM B88, Type L; cast or wrought-copper, solder-joint fittings; and brazed joints or pressed copper fittings.

3.12. VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Ball valves.

2. Throttling Duty: Use ball or globe valves.

3. Hot-Water Circulation Piping, Balancing Duty: Calibrated balancing valves.

4. Drain Duty: Hose-end drain valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

END OF SECTION 221116

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SECTION 221119 – DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes special duty valves and specialties for domestic water piping systems.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

B. Closeout Submittals:

1. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1. GENERAL REQUIREMENTS

A. Potable-water piping and components shall comply with NSF 61 Annex G.

2.2. PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.3. VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers: ASSE 1001, bronze body with rough bronze finish and threaded connections.

1. Size: 1/4 to 3-inches NPS, as required to match connected piping.

B. Hose-Connection Vacuum Breakers: ASSE 1011, non-removable bronze body with manual seal, finish to match hose bib, and ASME B1.20.7 garden-hose threaded end.

2.4. BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:

1. Standard: ASSE 1013.

2. Operation: Continuous-pressure applications.

3. Pressure Loss: 12 psig maximum, through middle third of flow range.

4. Size: As noted on drawings.

5. Body: Bronze for NPS 2 and smaller; stainless steel or cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.

6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
7. Accessories:
    a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
    b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type.
    c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

B. Beverage-Dispensing-Equipment Backflow Preventers:
1. Standard: ASSE 1022.
2. Operation: Continuous-pressure applications.
3. Size: NPS 1/4 or NPS 3/8.
4. Body: Stainless steel.
5. End Connections: Threaded.

C. Hose-Connection Backflow Preventers:
1. Standard: ASSE 1052.
2. Operation: Up to 10-foot head of water back pressure.
3. Inlet Size: NPS 1/2 or NPS 3/4.
4. Outlet Size: Garden-hose thread complying with ASME B1.20.7.
5. Capacity: At least 3-gpm flow.

D. Backflow-Preventer Test Kits:
1. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.5. BALANCING VALVES

A. Stainless Steel Thermostatic Control Valves:
1. Type: Factory Set automatic control valve at 110 °F for proper hot water recirculation system balancing.
2. Size: Same as connected piping, but not smaller than NPS 3/4.

B. Stainless Steel Automatic Flow Control Valves:
1. Type: Factory Set automatic control valve at required GPM for proper hot water recirculation system balancing.
2. Size: Same as connected piping, but not smaller than NPS 3/4.

2.6. TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Individual-Fixture, Water Tempering Valves:
1. Standard: ASSE 1016, thermostatically controlled, water tempering valve.

2. Pressure Rating: 125 psig minimum unless otherwise indicated.
3. Body: Bronze body with corrosion-resistant interior components.
4. Temperature Control: Adjustable.
5. Inlets and Outlet: Threaded.
6. Finish: Rough or chrome-plated bronze.

2.7. STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations unless otherwise indicated.
5. Perforation Size:
   a. Strainers 2-inches NPS and Smaller: 0.020-inch.
   b. Strainers 2-1/2 to 4-inches NPS: 0.045-inch
6. Drain: Threaded outlet with plug.

2.8. OUTLET BOXES

A. Clothes Washer Outlet Boxes:

1. Mounting: Recessed.
2. Material and Finish: Enameled-steel, epoxy-painted-steel, or plastic box and faceplate.
3. Faucet: Combination valved fitting or separate hot- and cold-water valved fittings complying with ASME A112.18.1. Include garden-hose thread complying with ASME B1.20.7 on outlets.
4. Supply Shutoff Fittings: 1/2-inch NPS ball valves and 1/2-inch NPS copper, water tubing.
5. Drain: 2-inches NPS standpipe and P-trap for direct waste connection to drainage piping.

B. Refrigerator Icemaker Outlet Boxes:

1. Mounting: Recessed.
2. Material and Finish: Enameled-steel, epoxy-painted-steel, or plastic box and faceplate.
3. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
4. Supply Shutoff Fitting: NPS 1/2 ball valve and NPS 1/2 copper, water tubing.

2.9. HOSE BIBBS

A. Hose Bibbs: ASME A112.18.1 with bronze body with replaceable bronze seat, 3/4-inch threaded or solder-joint supply connection, and ASME B1.20.7 garden-hose thread. Rated for 125 psig. Include operating key with each operating-key hose bibb

1. Vacuum Breaker: Integral or non-removable, drainable, hose-connection vacuum breaker complying with ASSE 1011.

2. Finish:

a. Equipment Rooms: Rough bronze, or chrome plated.

b. Service Areas: Rough bronze Chrome plated.

c. Finished Rooms: Chrome or nickel plated.

3. Operation:

a. Equipment Rooms: Wheel handle or operating key.

b. Service Areas: Wheel handle or Operating key.

c. Finished Rooms: Operating key.

4. Include operating key with each operating-key hose bibb.

5. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.10. WALL HYDRANTS

A. Non-Freeze Wall Hydrants:

1. Standard: ASME A112.21.3M for concealed outlet, self-draining wall hydrants.

2. Pressure Rating: 125 psig.

3. Operation: Loose key.

4. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.

5. Inlet: NPS 3/4.

6. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.

7. Box: Deep, flush mounted with cover.

8. Box and Cover Finish: Polished nickel bronze.

9. Operating Key: One with each wall hydrant.

2.11. DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.

2. Pressure Rating: 400-psig minimum CWP.

3. Size: 3/4-inch NPS.

4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

2.12. WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

1. Standard: ASSE 1010 or PDI-WH 201.
2. Type: Stainless steel bellows type..
3. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.13. TRAP-SEAL PRIMER DEVICE

A. Supply-Type, Trap-Seal Primer Device:

1. Standard: ASSE 1018 for pressure-initiated devices and ASSE 1044 for Flush Valve mounted trap primers.
2. Pressure Rating: 125 psig minimum.
3. Body: Bronze.
4. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
5. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
6. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

B. Drainage Type, Trap-Seal Primer Device:

1. Standard: ASSE 1044, lavatory P-trap with NPS 3/8 minimum, trap makeup connection.
2. Size: NPS 1-1/4-inch NPS minimum.
3. Material: Chrome-plated, cast brass.

2.14. SPECIALTY VALVES

A. Comply with requirements for general-duty metal valves in Section 220523.

2.15. FLEXIBLE CONNECTORS

A. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig.

2. End Connections 2-inches NPS and Smaller: Threaded copper pipe or plain-end copper tube.

3. End Connections 2-1/2-inches NPS and Larger: Flanged copper alloy.

B. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig.

2. End Connections 2-inches NPS and Smaller: Threaded steel-pipe nipple.

3. End Connections 2-1/2-inches NPS: Flanged steel nipple.

PART 3 - EXECUTION

3.1. INSTALLATION

A. Comply with requirements for ground equipment in Division 26.

3.2. LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Pressure vacuum breakers.

2. Reduced-pressure-principle backflow preventers.

3. Dual-check-valve backflow preventers.

4. Calibrated balancing valves.

5. Outlet boxes.

6. Supply-type, trap-seal primer valves.

7. Trap-seal primer systems.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553.

3.3. FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test each pressure vacuum breaker, reduced-pressure-principle backflow preventer, double-check, backflow-prevention assembly and double-check, detector-assembly backflow preventer according to authorities having jurisdiction and the device's reference standard.

B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.4. ADJUSTING

A. Set field-adjustable flow set points of balancing valves.

B. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION 221119

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SECTION 221123 – DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes domestic water recirculation pumps.

1.2. SUBMITTALS

A. Product Submittals:

1. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

2. Proposed pump data shall include all potential motor sizes, impeller sizes, total head, flow rates and efficiency curves. Pump curves showing only the proposed selection point data is not acceptable.

B. Closeout Submittals:

1. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.3. COORDINATION

A. Coordinate electrical connections and locations with actual equipment provided.

1.4. EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide product by one of the following:

1. Bell & Gossett.

2. Xylem.

3. Grundfos.

2.2. INLINE, SEALLESS CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, in-line, close-coupled, canned-motor, sealless, overhung-impeller centrifugal pumps.

1. Pump Construction:

    a. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge type with motor and impeller on common shaft and designed for installation with pump and motor shaft horizontal.

    b. Casing: Bronze, with threaded or companion-flange connections.

    c. Impeller: Bronze or stainless steel.

    d. Motor: Single speed, unless otherwise indicated.

PART 3 - EXECUTION

3.1. EXAMINATION

A. Examine roughing-in for domestic water piping systems to verify actual locations of piping connections before pump installation.

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

3.2. PUMP INSTALLATION

A. Comply with HI 1.4 and HI 2.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Install centrifugal pumps with shaft horizontal unless otherwise indicated.

D. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

E. Install in-line pumps with continuous-thread hanger rods and spring hangers with vertical-limit stop of size required to support weight of in-line pumps.

3.3. CONNECTIONS

A. Comply with requirements for piping specified in Section 22 11 16. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to pumps to allow service and maintenance.

C. Connect domestic water piping to pumps.

D. Install check, shutoff, and throttling valves on discharge side of pumps not equipped with a variable speed drive.

E. Install Y-type strainer and shutoff valve on suction side of inline pumps.

F. Connect thermostats, time-delay relays, and timers to pumps that they control.

G. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping or install single gage with multiple-input selector valve. A single differential pressure gauge is not acceptable.

H. Ground equipment according to Division 26 specifications.

I. Connect wiring according to Division 26 specifications.

3.4. STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Set thermostats, timers, and time-delay relays for automatic starting and stopping operation of pumps.
5. Perform the following startup checks for each pump before starting:
    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in the correct direction.
6. Prime pump by opening suction valves and closing drains and prepare pump for operation.
7. Start motor.
8. Open discharge valve slowly.
9. Adjust temperature settings on thermostats.
10. Adjust timer settings.

3.5. ADJUSTING

A. Adjust domestic water pumps to function smoothly and lubricate as recommended by manufacturer.

B. Adjust initial temperature set points.

C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.6. DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain domestic water pumps.

END OF SECTION 221123

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SECTION 221316 – SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes pipe and fitting materials and joining methods for sanitary waste and vent piping.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

PART 2 - PRODUCTS

2.1. PERFORMANCE REQUIREMENTS

A. Sanitary waste and vent piping and components shall be capable of withstanding 10-feet head of water at 75 °F in gravity systems. Piping systems shall be pressure tested, leak tested, and flushed.

2.2. PIPING MATERIALS

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.3. HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: Hub-less cast iron pipe and fittings shall be manufactured from gray cast iron and shall conform to ASTM A888 and CISPI Standard 301. All pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute and listed by NSF International.

B. Heavy-Duty, Hubless-Piping Couplings: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop. Comply with ASTM C1540.

2.4. COPPER TUBE AND FITTINGS

A. DWV Copper Tubing: ASTM B 306, Type DWV.

B. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

C. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.5. PVC PIPE AND FITTINGS

A. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-DWV" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

B. Solid-Wall PVC Pipe: ASTM D2665, drain, waste, and vent.

C. PVC Socket Fittings: ASTM D2665, made to ASTM D3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

D. Adhesive Primer: ASTM F656.

1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Solvent Cement: ASTM D2564.

1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.6. SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

2. Shielded, Non-Pressure Transition Couplings:

a. Standard: ASTM C1460.

b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

c. End Connections: Same size as and compatible with pipes to be joined.

B. Dielectric Fittings:

1. Dielectric Unions, 2-inches NPS and Smaller: Factory-fabricated ASSE 1079 rated for 125 psig at 180 deg F with solder-joint copper alloy and threaded ferrous end connections.

2. Dielectric Flanges, 2-1/2 to 4-inches NPS: Factory-fabricated, bolted, companion-flange assembly, ASSE 1079 rated for 125 psig at 180 deg F with solder-joint copper alloy and threaded ferrous end connections.

PART 3 - EXECUTION

3.1. EARTH MOVING

A. Comply with requirements of Section 220100 and Division 33.

3.2. PIPING APPLICATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.

1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.

2. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping at indicated slopes.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Install piping to allow application of insulation.

I. Make changes in direction for sanitary waste and vent piping using appropriate branches, bends, and long-sweep bends.

1. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.

2. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe.

a. Straight tees, elbows, and crosses may be used on vent lines.

3. Do not change direction of flow more than 90 degrees.

4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.

a. Reducing size of waste piping in direction of flow is prohibited.

J. Lay buried building waste piping beginning at low point of each system.

1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.

2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

3. Maintain swab in piping and pull past each joint as completed.

K. Install sanitary waste and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Waste: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.

2. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

L. Install steel piping according to applicable plumbing code.

M. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."

N. Install underground PVC piping according to ASTM D2321.

O. Plumbing Specialties:

1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping. Comply with requirements for cleanouts specified in Section 221319.

2. Install drains in sanitary waste gravity-flow piping. Comply with requirements for drains specified in Section 221319.

P. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220100.

R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220100.

S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220100.

3.3. JOINT CONSTRUCTION

A. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

B. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1.

1. Cut threads full and clean using sharp dies.

2. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

c. Do not use pipe sections that have cracked or open welds.

C. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.

D. Plastic, Non-Pressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.

2. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 appendixes.

3.4. SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in ODs.

2. In Waste Drainage Piping: Unshielded, non-pressure transition couplings.

B. Dielectric Fittings: Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

3.5. VALVE INSTALLATION

A. Comply with requirements in Section 220523 for general-duty valve installation requirements.

B. Shutoff Valves:

1. Install shutoff valve on each sump pump discharge.

2. Install full-port ball valve for piping 2-inches NPS and smaller.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

3.6. HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529.

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.

2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.

3. Vertical Piping: MSS Type 8 or Type 42, clamps.

4. Install individual, straight, horizontal piping runs:

a. MSS Type 1, adjustable, steel clevis hangers.

5. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.

6. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support horizontal piping and tubing within twelve (12) inches of each fitting, valve, and coupling.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. 1-1/2 and 2-inches NPS: 60 inches with 3/8-inch rod.

2. 3-inches NPS: 60 inches with 1/2-inch rod.

3. 4 to 5-inches NPS: 60 inches with 1/2-inch rod.

4. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

F. Install supports for vertical cast-iron soil piping every 15 feet.

G. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. 2-inches NPS: 96 inches with 3/8-inch rod.

H. Install supports for vertical copper tubing every 10 feet.

I. Support piping and tubing not listed above according to MSS SP-58 and manufacturer's written instructions.

3.7. CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect sanitary waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect waste and vent piping to the following:

1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.

2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.

3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.

4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.

5. Comply with requirements for cleanouts and drains specified in Section 221319.

6. Equipment: Connect waste piping as indicated.

a. Provide shutoff valve if indicated and union for each connection.

b. Use flanges instead of unions for connections 2-1/2-inches NPS and larger.

D. Connect force-main piping to the following:

1. Sump Pump: To pump discharge.

E. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

F. Make connections according to the following unless otherwise indicated:

1. Install unions, in piping 2-inches NPS and smaller, adjacent to each valve and at final connection to each piece of equipment.

3.8. IDENTIFICATION

A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Section 220553.

3.9. FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.

2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Re-inspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for re-inspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary waste and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced waste and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.

a. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.

b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.

c. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight.

a. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg.

b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.

c. Air pressure must remain constant without introducing additional air throughout period of inspection.

d. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

6. Prepare reports for tests and required corrective action.

3.10. CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

D. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

E. Repair damage to adjacent materials caused by waste and vent piping installation.

3.11. PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground, sanitary waste and vent piping shall be:

1. Hubless, cast-iron soil pipe and fittings; CISPI heavy-duty hubless-piping couplings; and coupled joints.

2. Dissimilar Pipe-Material Couplings: Unshielded, non-pressure transition couplings.

C. Underground, sanitary waste and vent piping shall be:

1. Solid Wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

2. Dissimilar Pipe-Material Couplings: Unshielded, non-pressure transition couplings.

D. Sump pump discharge shall be either of the following:

1. Galvanized-steel pipe, pressure fittings, and threaded joints.

END OF SECTION 221316

SECTION 221319 – SANITARY WASTE AND VENT PIPING SPECIALTIES

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes piping specialties for sanitary waste and vent piping.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1.3. QUALITY ASSURANCE

A. Pipe materials shall bear label or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1. ASSEMBLY DESCRIPTIONS

A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.

2.2. CAST-IRON FLOOR DRAINS:

A. Cast-Iron Floor Drains: ASME A112.6.3. Pattern: Area drain, Gray iron body with seepage flange and clamping device. Floor drains for installation in floor not having membrane waterproofing may have seepage flange without clamping device. Bottom outlet. Heavy Duty Bronze strainer.

1. General: Size outlets as indicated on the drawings.

2.3. CAST-IRON FLOOR SINKS:

A. Cast-Iron Floor Drains: ASME A112.6.3. Gray iron body with seepage flange and half-grate. Bottom outlet. Heavy Duty Bronze strainer.

1. General: Size outlets as indicated on the drawings.

2.4. CLEANOUTS

A. Cast-Iron Exposed Cleanouts: ASME A112.36.2M for cast iron cleanout and test tee. Size: Same as connected drainage piping. Body Material shall be hubless, cast-iron soil pipe test tee as required to match connected piping with a countersunk head plastic plug. Closure Plug Size: Same as cleanout size.

B. Cast-Iron Exposed Floor Cleanouts: ASME A112.36.2M for adjustable housing cleanout. Sized the same as connected branch. Cast iron body with spigot outlet connection and plastic plug. Adjustable Housing shall be Cast iron with threads. Frame and Cover Material and Finish: Painted cast iron with round cover. Medium Duty top loading classification and an ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts: ASME A112.36.2M. Include wall access. Size: Same as connected drainage piping. Hub-less, cast-iron soil pipe test tee as required to match connected piping. Countersunk cast iron plug with plug size same as cleanout size. Wall Access: Round, flat, stainless-steel cover plate with screw.

2.5. MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564 rubber gaskets. Size: Same with increaser fitting of size indicated.

B. Floor-Drain, Trap-Seal Primer Fittings: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection. Size: Same as floor drain outlet with 1/2-inch NPS side inlet.

PART 3 - EXECUTION

3.1. INSTALLATION

A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to 4-inches NPS. Use 4-inches NPS for larger drainage piping unless larger cleanout is indicated.

2. Locate at each change in direction of piping greater than 45 degrees.

3. Locate at minimum intervals of 50 feet for piping 4-inches NPS and smaller and 100 feet for larger piping.

4. Locate at base of each vertical sanitary waste stack.

B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

D. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof. Comply with requirements in Division 7.

E. Install through-penetration firestop assemblies in accordance to the requirements in Section 220500.

F. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.

1. Exception: Fitting may be omitted if trap has trap-seal primer connection.

G. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

H. Install sleeve and sleeve seals with each riser and stack passing through floors with waterproof membrane.

I. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

J. Install wood-blocking reinforcement for wall-mounting-type specialties.

K. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2. CONNECTIONS

A. Comply with requirements in Section 221316 for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Ground equipment according to Division 26.

D. Connect wiring according to Division 26.

3.3. FLASHING INSTALLATION

A. Comply with requirements in Division 7.

B. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required.

C. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10-inches, and skirt or flange extending at least 8-inches around pipe.

2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.

3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

D. Set flashing on floors and roofs in solid coating of bituminous cement. For membrane roofs coordinate adhesive requirements with roofing contractor. Use adhesives compatible with roofing material.

E. Secure flashing into sleeve and specialty clamping ring or device.

F. Install flashing for piping passing through roofs with counter-flashing or commercially made flashing fittings, according to Division 7.

G. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

3.4. LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each piece of equipment.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553.

3.5. FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

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

3.6. PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319

SECTION 221323 – SANITARY WASTE INTERCEPTORS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes grease interceptors and solids interceptors.

1.2. SUBMITTALS

A. Product Submittals: For each type of interceptor. Include materials of fabrication, dimensions, rated capacities, retention capacities, operating characteristics, size and location of each pipe connection, furnished specialties, and accessories.

PART 2 - PRODUCTS

2.1. GREASE INTERCEPTORS

A. Precast Concrete Grease Interceptors: Comply with ASTM C913 and authorities having jurisdiction.

1. Include rubber-gasketed joints, vent connections, manholes, compartments or baffles, and piping or openings to retain grease and to permit wastewater flow.
2. Structural Design Loads:
    a. Heavy-Traffic Load: Comply with ASTM C890, A-16.
3. Characteristics:
    a. Capacity: As identified on drawings.
    b. Number of Compartments: Two.
    c. Inlet and Outlet Pipe Size: As identified on the drawings.
    d. Installation Position: Underground with manhole risers to grade.

B. SOLIDS INTERCEPTORS:

1. Standard: ASME A112.14.3, for intercepting and retaining food waste from food-preparation wastewater.
2. Body Material: Stainless steel.
3. Inlet and Outlet Pipe Size: 3”.
4. End Connections: No-Hub.
5. Cleanout: field installed on outlet.
6. Mounting: On floor.
7. Flow-Control Fitting: Not Required.

8. Operation: Manual cleaning.

9. Capacity: As identified on drawings.

2.2. PRECAST CONCRETE MANHOLE RISERS

A. Precast Concrete Manhole Risers: ASTM C 478, with rubber-gasket joints.

1. Structural Design Loads:

a. Heavy-Traffic Load: Comply with ASTM C890, A-16.

2. Length: From top of underground concrete structure to grade.

3. Riser Sections: 3-inch minimum thickness and 24-inch diameter.

4. Top Section: Eccentric cone, unless otherwise indicated. Include top of cone to match grade ring size.

5. Gaskets: ASTM C443, rubber.

6. Steps: Individual FRP steps or FRP ladder, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12 to 16-inch intervals.

B. Grade Rings: Reinforced-concrete rings, 6 to 9-inch total thickness, diameter matching manhole frame and cover, and height as required to adjust the manhole frame and cover to indicated elevation and slope.

C. Manhole Frames and Covers: Ferrous; 24-inch ID by 7- to 9-inch riser with 4-inch- minimum width flange and 26-inch- diameter cover.

1. Ductile Iron: ASTM A536, Grade 60-40-18, unless otherwise indicated.

2. Gray Iron: ASTM A48, Class 35, unless otherwise indicated.

3. Include indented top design with lettering cast into cover, using wording equivalent to the following:

a. Grease Interceptors in Sanitary Sewerage System: "GREASE INTERCEPTOR”.

PART 3 - EXECUTION

3.1. EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 220100 and Division 3.

3.2. INSTALLATION

A. Install precast-concrete interceptors according to ASTM C891.

B. Set interceptors level and plumb.

C. Install manhole risers from top of underground concrete interceptors to manholes and gratings at finished grade.

D. Set tops of manhole frames and covers flush with finished surface in pavements.

1. Set tops 3 inches above finish surface elsewhere unless otherwise indicated.

E. Set tops of grating frames and grates flush with finished surface.

F. Install grease interceptors, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing.

1. Install cleanout immediately downstream from interceptors not having integral cleanout on outlet.

G. Install oil interceptors, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing.

3.3. CONNECTIONS

A. Piping installation requirements are specified in Section 221316. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Make piping connections between interceptors and piping systems.

3.4. IDENTIFICATION

A. Identification materials and installation are specified in Section 220553 and Division 3.

1. Use warning tapes or detectable warning tape over ferrous piping.

2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.5. PROTECTION

A. Protect sanitary waste interceptors from damage during construction period.

B. Repair damage to adjacent materials caused by sanitary waste interceptor installation.

END OF SECTION 221323

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SECTION 211429 – SUMP PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Submersible sump pumps.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Wiring Diagrams: For power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps and controls, to include in operation and maintenance manuals.

1.5 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. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

PART 2 - PRODUCTS

2.1 SUBMERSIBLE SUMP PUMPS

A. Submersible, Sump Pumps:

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:

a. Goulds Pumps; ITT Corporation.

b. Liberty Pumps.

c. Stancor, Inc.

d. Zoeller Company.

e. Myers Pumps.

2. Description: Factory assembled and tested sump pump unit.

3. Pump Type: Submersible, single-stage, close-coupled, centrifugal sump pump.

4. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.

5. Impeller: Statically and dynamically balanced, cast bronze, non-clog design for clear wastewater handling, and keyed and secured to shaft.

6. Pump and Motor Shaft: stainless steel, with factory-sealed, grease-lubricated ball bearings.

7. Seal: Mechanical.

8. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.

9. Controls:

a. Enclosure: NEMA 250, Type 4.

b. Switch Type: Pump mounted float switch and oil-detection probe.

c. High-Water Alarm: discharge pipe mounted, mercury float switch with cable length as required between float switch and control panel.

10. Control-Interface Features:

a. Remote Alarm Contacts: For remote alarm interface.

b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:

1) On-off status of pump.

2) Alarm status.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for plumbing piping to verify actual locations of storm drainage piping connections before sump pump installation.

3.2 INSTALLATION

A. Pump Installation Standards: Comply with HI 1.4 for installation of sump pumps.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Section 2211316. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including conections, and to assist in testing.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection.

2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning conrols and equipment.

D. Pumps and controls will be considered defective if they do not pass tests and inspecions.

E. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks, according to manufacturer's written instructions.

3.6 ADJUSTING

A. Adjust pumps to function smoothly and lubricate as recommended by manufacturer.

B. Adjust control set points.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

END OF SECTION 221429

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SECTION 222316 – FUEL GAS PIPING

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes piping, fittings, specialties, valves, regulators, and meters for fuel gas piping systems.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

B. Closeout Submittals:

1. Operation and Maintenance Data: For valves and pressure regulators to include in emergency, operation, and maintenance manuals.

1.3. COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces.

PART 2 - PRODUCTS

2.1. PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.

2. Service Regulators: 100 psig minimum unless otherwise indicated.

B. Liquified Petroleum Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 0.5 psig but not more than 2 psig and is reduced to secondary pressure of 0.5 psig or less.

2.2. PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A53, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.

2. Wrought-Steel Welding Fittings: ASTM A234 for butt welding and socket welding.

3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.

4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

a. Material Group: 1.1.

b. End Connections: Threaded or butt welding to match pipe.

c. Lapped Face: Not permitted underground.

d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound met-al gaskets.

e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

5. 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.

6. Mechanical Couplings:

a. Stainless-steel flanges and tube with epoxy finish.

b. Buna-nitrile seals.

c. Stainless-steel bolts, washers, and nuts.

d. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.

e. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

B. PE Pipe: ASTM D2513, SDR 11.

1. PE Fittings: ASTM D2683, socket-fusion type or ASTM D3261, butt-fusion type with dimensions matching PE pipe.

2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D2513, SDR 11; and steel pipe complying with ASTM A53, black steel, Schedule 40, Type E or S, Grade B.

3. Anodeless Service-Line Risers: Factory-fabricated and leak tested.

a. Underground Portion: PE pipe complying with ASTM D2513, SDR 11 inlet.

b. Casing: Steel pipe complying with ASTM A53, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering. Vent casing aboveground.

c. Aboveground Portion: PE transition fitting.

d. Outlet shall be threaded or flanged or suitable for welded connection.

e. Tracer wire connection.

f. Ultraviolet shield.

g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

4. Transition Service-Line Risers: Factory-fabricated and leak tested.

a. Underground Portion: PE pipe complying with ASTM D2513, SDR 11 inlet connected to steel pipe complying with ASTM A53, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.

b. Outlet shall be threaded or flanged or suitable for welded connection.

c. Bridging sleeve over mechanical coupling.

d. Factory-connected anode.

e. Tracer wire connection.

f. Ultraviolet shield.

g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

2.3. PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.

2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.

3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.

4. CWP Rating: 125 psig.

B. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.4. JOINING MATERIALS

A. Joint Compound and Tape: Suitable for LP gas.

B. Welding Filler Metals: Comply with AWS D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.5. MANUAL GAS SHUTOFF VALVES

A. See "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.

1. CWP Rating: 125 psig.

2. Threaded Ends: Comply with ASME B1.20.1.

3. Dry-Seal Threads on Flare Ends: Comply with ASME B1.20.3.

4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.

5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.

6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.

1. CWP Rating: 125 psig.

2. Flanged Ends: Comply with ASME B16.5 for steel flanges.

3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.

4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. Body: Bronze, complying with ASTM B584.

2. Ball: Chrome-plated bronze.

3. Stem: Bronze; blowout proof.

4. Seats: Reinforced TFE; blowout proof.

5. Packing: Threaded-body packnut design with adjustable-stem packing.

6. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.

7. CWP Rating: 600 psig.

8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.

9. Service: Suitable for LP-gas service with "WOG" indicated on valve body.

E. Bronze Plug Valves: MSS SP-78.

1. Body: Bronze, complying with ASTM B584.

2. Plug: Bronze.

3. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.

4. Operator: Square head or lug type with tamperproof feature where indicated.

5. Pressure Class: 125 psig.

6. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.

7. Service: Suitable for LP-gas service with "WOG" indicated on valve body.

F. Cast-Iron, Non-Lubricated Plug Valves: MSS SP-78.

1. Body: Cast iron, complying with ASTM A126, Class B.

2. Plug: Bronze or nickel-plated cast iron.

3. Seat: Coated with thermoplastic.

4. Stem Seal: Compatible with LP gas.

5. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.

6. Operator: Square head or lug type with tamperproof feature where indicated.

7. Pressure Class: 125 psig.

8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.

9. Service: Suitable for LP-gas service with "WOG" indicated on valve body.

2.6. MOTORIZED GAS VALVES

A. Electrically Operated Valves: Comply with UL 429.

1. Pilot operated.

2. Body: Brass or aluminum.

3. Seats and Disc: Nitrile rubber.

4. Springs and Valve Trim: Stainless steel.

5. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.

6. NEMA ICS 6, Type 4, coil enclosure.

7. Normally closed.

8. Visual position indicator.

2.7. PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for LP gas.

2. Steel jacket and corrosion-resistant components.

3. Elevation compensator.

4. End Connections: Threaded for valves 2-inches NPS and smaller; flanged for valves 2-1/2-inches NPS and larger.

B. Service Pressure Regulators: Comply with ANSI Z21.80.

1. Body and Diaphragm Case: Cast iron or die-cast aluminum.

2. Springs: Zinc-plated steel; interchangeable.

3. Diaphragm Plate: Zinc-plated steel.

4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.

5. Orifice: Aluminum; interchangeable.

6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.

7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.

8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.

9. Overpressure Protection Device: Factory mounted on pressure regulator.

10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.

11. Maximum Inlet Pressure: 100 psig.

C. Line Pressure Regulators: Comply with ANSI Z21.80.

1. Body and Diaphragm Case: Cast iron or die-cast aluminum.

2. Springs: Zinc-plated steel; interchangeable.

3. Diaphragm Plate: Zinc-plated steel.

4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.

5. Orifice: Aluminum; interchangeable.

6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.

7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.

8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.

9. Overpressure Protection Device: Factory mounted on pressure regulator.

10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.

11. Maximum Inlet Pressure: 2 psig

D. Appliance Pressure Regulators: Comply with ANSI Z21.18.

1. Body and Diaphragm Case: Die-cast aluminum.

2. Springs: Zinc-plated steel; interchangeable.

3. Diaphragm Plate: Zinc-plated steel.

4. Seat Disc: Nitrile rubber.

5. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.

6. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.

7. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.

8. Maximum Inlet Pressure: 0.5 psig

2.8. DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

1. Description:

a. Standard: ASSE 1079.

b. Pressure Rating: 125 psig minimum at 180 °F.

c. End Connections: Solder-joint copper alloy and threaded ferrous.

2.9. LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.1. EXAMINATION

A. Examine roughing-in for LP-gas piping system to verify actual locations of piping connections be-fore equipment installation.

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

3.2. PREPARATION

A. Close equipment shutoff valves before turning off LP gas to premises or piping section.

B. Inspect LP-gas piping according to NFPA 54 the International Fuel Gas Code to determine that LP-gas utilization devices are turned off in piping section affected.

C. Comply with NFPA 54 the International Fuel Gas Code requirements for prevention of accidental ignition.

3.3. OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 54 the International Fuel Gas Code for installation and purging of LP-gas piping.

B. Install underground, LP-gas piping buried at least 36 inches below finished grade. Comply with requirements in Section 220100 and Division 31 for excavating, trenching, and backfilling.

1. If LP-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.

C. Install underground, PE, LP-gas piping according to ASTM D2774.

D. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.

2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.

3. Replace pipe having damaged PE coating with new pipe.

E. Copper Tubing with Protective Coating:

1. Apply joint cover kits over tubing to cover, seal, and protect joints.

2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.

F. Install fittings for changes in direction and branch connections.

G. Install pressure gage upstream and downstream from each service regulator. Pressure gages are specified in Section 230519.

3.4. INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 the International Fuel Gas Code for installation and purging of LP-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install LP-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

N. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

O. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

P. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

Q. Concealed Location Installations: Except as specified below, install concealed LP-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as

described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.

1. Above Accessible Ceilings: LP-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.

2. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.

    a. Exception: Tubing passing through partitions or walls does not require striker barriers.

3. Prohibited Locations:

    a. Do not install LP-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.

    b. Do not install LP-gas piping in solid walls or partitions.

R. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

S. Connect branch piping from top or side of horizontal piping.

T. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

U. Do not use LP-gas piping as grounding electrode.

V. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

W. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Section 230519.

X. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220100.

Y. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220100.

Z. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220100.

3.5. VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install earthquake valves aboveground outside buildings according to listing.

E. Install anode for metallic valves in underground PE piping.

3.6. PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.

2. Cut threads full and clean using sharp dies.

3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.

4. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.

5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12, using qualified processes and welding operators.

2. Bevel plain ends of steel pipe.

3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.

1. Plain-End Pipe and Fittings: Use butt fusion.

2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.7. HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hangers and supports specified in Section 220529.

B. Install hangers for horizontal steel piping with maximum spacing and minimum rod sizes that comply with Section 220529.

C. Install hangers for horizontal drawn-temper copper tubing with maximum spacing and minimum rod sizes that comply with Section 220529.

D. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod sizes:

1. Piping 3/8-inch NPS: Maximum span, 4 feet; minimum rod size, 3/8 inch.

2. Piping 1/2-inch NPS: Maximum span, 6 feet; minimum rod size, 3/8 inch.

3. Piping 3/4-inch NPS and larger: Maximum span, 8 feet; minimum rod size, 3/8 inch.

3.8. CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install LP-gas piping electrically continuous and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.9. LABELING AND IDENTIFYING

A. Comply with requirements in Section 220553 for piping and valve identification.

3.10. FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Test, inspect, and purge LP gas according to NFPA 54 the International Fuel Gas Code and authorities having jurisdiction.

B. Prepare test and inspection reports.

3.11. OUTDOOR PIPING SCHEDULE

A. Underground LP-gas piping shall be the following:

1. PE pipe and fittings joined by heat fusion, or mechanical couplings; service-line risers with tracer wire terminated in an accessible location.

B. Aboveground LP-gas piping shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.

2. Steel pipe with wrought-steel fittings and welded joints.

C. Branch Piping in Cast-in-Place Concrete to Single Appliance: Annealed-temper copper tube with wrought-copper fittings and [brazed] [flared] joints. Install piping embedded in concrete with no joints in concrete.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.12. INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 5.0 PSIG

A. Aboveground, branch piping 1-inch NPS and smaller shall be the following:

1. Annealed-temper, copper tube with wrought-copper fittings and brazed joints.

2. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.

2. Steel pipe with wrought-steel fittings and welded joints.

3. Drawn-temper copper tube with wrought-copper fittings and brazed joints.

C. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

D. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.13. ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes 2-inches NPS and smaller at service meter shall be the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

B. Valves for pipe sizes 2-1/2-inches NPS and larger at service meter shall be the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.
3. Cast-iron, non-lubricated plug valve.

C. Distribution piping valves for pipe sizes 2-inches NPS and smaller shall be the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

D. Distribution piping valves for pipe sizes 2-1/2-inches NPS and larger shall be the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.
3. Cast-iron, non-lubricated plug valve.

E. Valves in branch piping for single appliance shall be the following:

1. Two-piece, regular-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

END OF SECTION 222316

SECTION 223400 – FUEL-FIRED DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes fuel-fired domestic water heaters and accessories.

1.2. SUBMITTALS

A. Product Submittals:

1. Product Data: For each type and size of domestic-water heater indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

2. Wiring Diagrams: For power, signal, and control wiring.

B. Closeout Submittals:

1. Operation and Maintenance Data: For domestic-water heaters to include in emergency, operation, and maintenance manuals.

1.3. QUALITY CONTROL

A. Factory Tests: Test and inspect domestic-water heaters specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test domestic-water heaters to minimum of one and one-half times pressure rating before shipment.

1.4. WARRANTY

A. Manufacturer's Warranty: Provide manufacturer’s warranty to repair or replace components of the water heaters that fail in materials or workmanship within specified warranty period. Warranty period shall start at the date of owner accepted substantial completion. Warranty repairs and replacements shall include all parts and labor.

1. All Components: 3 year.

2. Tankless Heaters: 5 years.

3. Compression Tanks: 5 years.

PART 2 - PRODUCTS

2.1. FUEL-FIRED TANKLESS DOMESTIC WATER HEATERS

A. Manufacturers: Provide tankless water heaters that comply with the construction documents and are manufactured by one of the following:

1. Navien.

2. Rinnai.

3. A.O. Smith.

B. Standard: ANSI Z21.10.3/CSA 4.3 for gas-fired, instantaneous, domestic-water heaters for indoor application.

C. Construction: Copper piping or tubing complying with NSF 61 Annex G barrier materials for potable water, without storage capacity.

1. Connections: ASME B1.20.1 pipe thread.

2. Pressure Rating: 150 psig.

3. Heating Element: Copper tubing.

4. Insulation: Comply with ASHRAE/IESNA 90.1.

5. Jacket: Metal, with enameled finish, or plastic.

6. Burner: For use with tankless, domestic-water heaters and natural-gas fuel.

7. Automatic Ignition: Manufacturer's proprietary system for automatic, gas ignition.

8. Temperature Control: Adjustable thermostat. Support: Bracket for wall mounting.

2.2. DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Compression Tanks:

1. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air pre-charge to minimum system-operating pressure at tank.

2. Construction:

a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.

b. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.

c. Air-Charging Valve: Factory installed.

B. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1.

C. Heat-Trap Fittings: ASHRAE 90.2.

D. Comply with requirements for ball shutoff valves specified in Section 220523.

E. Comply with requirements for balancing valves specified in Section 221119.

F. Gas Shutoff Valves: ANSI Z21.15/CSA 9.1-M, manually operated. Furnish for installation in piping.

G. Gas Pressure Regulators: ANSI Z21.18/CSA 6.3, appliance type. Include 1/2-psig pressure rating as required to match gas supply.

H. Combination Temperature-and-Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.

1. Gas-Fired, Domestic-Water Heaters: ANSI Z21.22/CSA 4.4-M.

I. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4-M.

PART 3 - EXECUTION

3.1. DOMESTIC-WATER HEATER INSTALLATION

A. Tankless, Domestic-Water Heater Mounting: Install tankless, domestic-water heaters at least 18 inches above floor on wall bracket.

1. Maintain manufacturer's recommended clearances.

2. Arrange units so controls and devices that require servicing are accessible.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to supported equipment.

5. Anchor domestic-water heaters to substrate.

B. Install domestic-water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523.

C. Install gas-fired, domestic-water heaters according to NFPA 54.

1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.

2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.

3. Install automatic gas valves on gas supplies to gas-fired, domestic-water heaters if required for operation of safety control.

4. Comply with requirements for gas shutoff valves, gas pressure regulators, and automatic gas valves specified in Section 221123.

D. Install combination temperature-and-pressure relief valves in water piping for domestic-water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

E. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for electric, domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119.

F. Install thermometers on outlet piping of electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 220519.

G. Charge domestic-water compression tanks with air.

3.2. CONNECTIONS

A. Comply with requirements for domestic-water piping specified in Section 221116.

B. Comply with requirements for gas piping specified in Section 221123.

C. Drawings indicate general arrangement of piping, fittings, and specialties.

D. Where installing piping adjacent to fuel-fired, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3. IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553.

3.4. FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.

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

B. Prepare test and inspection reports.

3.5. DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain domestic-water heaters.

END OF SECTION 223400

SECTION 224000 – PLUMBING FIXTURES

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes commercial plumbing fixtures, fittings and supports.

B. Section includes:

1. Flush valve water closets.
2. Flush valve urinals.
3. Lavatories.
4. Electric water coolers.
5. Custodial sinks.
6. Sinks.
7. Showers.
8. Recessed valve boxes for refrigerator ice makers.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water closets.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Flow and water consumption requirements for fixture.
4. Shop Drawings: Include diagrams for power, signal, and control wiring.

B. Closeout Submittals:

1. Operation and Maintenance Data: For flushometer valves and electronic sensors to include in operation and maintenance manuals.
2. Operation and Maintenance Data: For sinks, lavatories, and faucets to include in operation and maintenance manuals.

1.3. EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Flushometer-Valve Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than six of each type.

2. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.

3. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.

PART 2 - PRODUCTS

2.1. WATER CLOSETS

A. Manufacturers: Subject to compliance with requirements, provide product by one of the following:

1. American Standard.

2. Kohler.

3. Zurn Industries.

B. Floor-Mounted, Bottom Outlet, Top Spud:

1. Description: White vitreous china, elongated rim, siphon jet type bowl with 1 1/2-inch NPS top spud and flushometer valve. Fixture shall comply with ASME A112.19.2 and ASME A112.19.5.

2. Height: Standard and ADA, complying with ICC/ANSI A117.1, as scheduled.

3. Water Consumption: 1.6 GPF, unless otherwise scheduled.

4. Bowl-to-Drain Connecting Fitting: ASTM A 1045 or ASME A112.4.3.

C. Wall-Mounted, Top Spud:

1. Description: White vitreous china, elongated rim, siphon jet type bowl with 1 1/2-inch NPS top spud and flushometer valve. Fixture shall comply with ASME A112.19.2 and ASME A112.19.5.

2. Height: Standard and ADA, complying with ICC/ANSI A117.1, as scheduled.

3. Water Consumption: 1.6 GPF, unless otherwise scheduled.

4. Support: Water Closet Carrier.

D. Toilet Seats:

1. Description: White plastic, elongated rim and open front, heavy-duty toilet seat with non-corroding metal, self-sustaining hinge. Seat shall comply with IAPMO/ANSI Z124.5. Manufactured by American Standard, Bemis, or Church.

2. Seat Cover: Not required unless otherwise scheduled.

2.2. URINALS

A. Manufacturers: Subject to compliance with requirements, provide product by one of the following:

1. American Standard.

2. Kohler.

3. Zurn Industries.

B. Wall-Hung, Back Outlet:

1. Description: White vitreous china, siphon jet type fixture with integral trap, 2-inch NPS back outlet, 3/4-inch NPS top spud, and flushometer valve. Fixture shall comply with ASME A112.19.2 and ASME A112.19.5.

2. Mounting Height: Standard and ADA, complying with ICC/ANSI A117.1, as scheduled.

3. Water Consumption: 1.0 GPF, unless otherwise scheduled.

4. Waste Fitting: 2-inch NPS complying with ASME A112.18.2 for coupling.

5. Support: ASME A112.6.1M, Type II, urinal carrier with hanger and bearing plates. Include rectangular, steel uprights.

2.3. FLUSHOMETER VALVES

A. Manufacturers: Subject to compliance with requirements, provide product by one of the following:

1. Sloan Valve Company.

2. Toto.

3. Zurn Industries.

4. Coyne and Delany.

5. Moen Commercial Brass.

B. Water Closet Lever-Handle:

1. Description: Exposed diaphragm flushometer style valve with minimum 1-inch NPS inlet and 1-1/2-inch NPS outlet, brass body, corrosion-resistant components, chrome-plated exposed finish, chrome-plated or stainless steel panel finish, and integral check stop and backflow-prevention device. Valve shall be rated for minimum 125 psig and comply with ASME 1037.

2. Water Consumption: 1.6 GPF, unless otherwise scheduled.

C. Urinal Lever-Handle:

1. Description: Exposed diaphragm flushometer style valve with minimum 3/4-inch NPS inlet and 3/4-inch NPS outlet, brass body, corrosion-resistant components, chrome-plated exposed finish, chrome-plated or stainless steel panel finish, and integral check stop and backflow-prevention device. Valve shall be rated for minimum 125 psig and comply with ASME 1037.

2. Water Consumption: 1.0 GPF, unless otherwise scheduled.

2.4. LAVATORIES

A. Manufacturers: Subject to compliance with requirements, provide product by one of the following:

1. American Standard.

2. Kohler.

3. Zurn Industries.

B. Wall-Mounted:

1. Description: White vitreous china with back for wall mounting. Fixture shall comply with ASME A112.19.2.

2. Nominal Size: As indicated in plumbing fixture schedule on sheets.

3. Faucet-Hole Location: Top.

4. Faucet-Hole Punching: 3 holes at 2-inch centers.

5. Faucet: Refer to the Plumbing Fixture Schedule.

6. Mounting Material: Chair carrier.

7. Mounting Height: Standard and ADA, complying with ICC/ANSI A117.1, as scheduled.

2.5. LAVATORY FAUCETS

A. Manufacturers: Subject to compliance with requirements, provide product by one of the following:

1. Delta Faucet.

2. Chicago Faucets.

3. Moen.

4. T & S Brass and Bronze Works.

B. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.

C. Lavatory Manually-Operated:

1. Description: Manually-operated, metering faucet with solid brass body, polished chrome plate finish, and hot and cold water indicators. Faucets shall comply with ASME A112.18.1. Coordinate faucet inlets with supplies and fixture hole punching. Coordinate outlet with spout and fixture receptor.

2. Maximum Flow Rate: 0.5 GPM.

3. Mounting Type: Deck, exposed.

4. Valve Handle(s): Metering

5. Spout: Rigid type.

6. Spout Outlet: Aerator.

2.6. ELECTRIC WATER COOLERS

A. Fountain:

1. ARI 1010; Surface mounted electric water cooler with stainless steel top, stainless steel body, elevated anti-squirt bubbler with stream guard, automatic stream regulator, push button, mounting bracket, refrigerated with integral air-cooled condenser and stainless steel grille. Provide with companion bottle filler, electronic pushbutton activation and drain.

2. Capacity: eight (8) gpm of fifty (50) °F water with inlet at eighty (80) °F and room temperature of ninety (90) °F.

3. Electrical: Maximum one-half (1/2) hp compressor, six (6) feet cord and plug for connection to electric wiring system including grounding connector.

B. Provide supply with replaceable inline cartridge water filter.

2.7. MOP RECEPTORS

A. Manufacturers: Subject to compliance with requirements, provide product by one of the following:

1. Acorn Engineering.
2. Fiat.
3. Florestone Products.
4. Stern-Williams Co.

B. Floor-Mounted Terrazzo:

1. Description: Terrazzo floor-mounted mop receptor with 3-inch NPS drain outlet, drain grid, rim guard on front top surface that mounts to the floor and flush to the wall. Basins shall comply with IAPMO PS 99.
2. Nominal Size: Refer to the Plumbing Fixture Schedule.
3. Height: 10 inches.
4. Faucet: A faucet with integral stops in shanks, vacuum breaker, hose-thread outlet, wall brace, and pail hook.

C. Floor-Mounted Molded Stone:

1. Description: Molded stone floor-mounted mop receptor with 3-inch NPS drain outlet, drain grid, rim guard on front top surface that mounts to the floor and flush to the wall. Basins shall comply with IAPMO/ANSI Z124.6.
2. Nominal Size: Refer to the Plumbing Fixture Schedule.
3. Height: 10 inches.
4. Faucet: A faucet with integral stops in shanks, vacuum breaker, hose-thread outlet, wall brace, and pail hook.

2.8. UTILITY SINKS

A. Manufacturers: Subject to compliance with requirements, provide product by one of the following:

1. Advance Tabco.
2. Eagle Group; Foodservice Equipment Division.
3. Elkay Manufacturing Co.
4. Just Manufacturing.

B. Free-Standing Stainless Steel Utility Sinks:

1. Description: Free-standing, single compartment, stainless steel utility sink with backsplash, centered drain with 1-1/2-inch NPS drain tailpiece and stopper, and adjustable length legs. Stainless steel shall be minimum 0.050-inches thick. Sinks shall comply with ASME A112.19.3.
2. Overall and Compartment Dimensions: Refer to the Plumbing Fixture Schedule.
3. Faucet: Single, wall mount, swivel gooseneck faucet with two wrist-blade handles.
    a. Mounting: On backsplash.

4. Supply Fittings: Chrome-plated brass compression stop with wheel handle and inlet connection matching water-supply piping type and size. Fittings shall comply with ASME A112.18.1.

    a. Risers: 1/2-inch NPS, chrome-plated, rigid-copper pipe.

5. Waste Fittings: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch- thick brass tube to wall and chrome-plated brass or steel wall flange. Fittings shall comply with ASME A112.18.2.

    a. Size: 1-1/2-inches NPS

C. Countertop Stainless Steel Sinks:

1. Description: Counter-mounted, drop-in, single compartment, stainless steel utility sink, centered drain with 1 1/2-inch NPS drain tailpiece and stopper. Stainless steel shall be minimum 0.050-inches thick. Sinks shall comply with ASME A112.19.3.

2. Overall and Compartment Dimensions: Refer to the Plumbing Fixture Schedule.

3. Faucet: Single handle, solid brass construction, chrome finish, with 2.2 gpm aerator.

4. Mounting: Deck mounted.

5. Supply Fittings: Chrome-plated brass compression stop with wheel handle and inlet connection matching water-supply piping type and size. Fittings shall comply with ASME A112.18.1.

6. Risers: 1/2-inch NPS, chrome-plated, rigid-copper pipe.

7. Waste Fittings: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch- thick brass tube to wall and chrome-plated brass or steel wall flange. Fittings shall comply with ASME A112.18.2.

8. Size: 1-1/2-inches NPS.

9. Mounting: On counter with sealant.

2.9. SUPPLY FITTINGS

A. Description: Supply piping shall be chrome-plated brass pipe or chrome-plated copper tube matching water-supply piping size including chrome-plated brass or stainless-steel wall flange. Supply stops shall be chrome-plated brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping. Fittings shall comply with ASME A112.18.1.

1. Risers: 1/2-inch NPS, chrome-plated, rigid-copper pipe.

B. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.

2.10. WASTE FITTINGS

A. Description: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch- thick brass tube to wall and chrome-plated brass or steel wall flange. Fittings shall comply with ASME A112.18.2.

1. Size: 1-1/2-inches NPS.

2. Drain: Grid type with 1-1/2-inches NPS offset and straight tailpiece.

3. Trap: 1-1/2-inches NPS.

2.11. SUPPORTS

A. Manufacturers: Subject to compliance with requirements, provide product by one of the following:

1. J.R. Smith Co.

2. Watts Water Technologies.

3. Zurn Industries.

B. Water Closet Carrier: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture. Carriers shall comply with ASME A112.6.1M.

2.12. SHOWERS

A. ADA compliant shower trim: ASME A112.18.1; concealed shower pressure balanced mixing valve, indexed control, integral service stops, bent shower arm with flow control and adjustable spray ball joint showerhead with escutcheon, hand held shower with sixty (60) inches metal clad hose and twenty-four (24) inches slide bar, female inlet; maximum 1.5 gpm flow. All internal parts shall be brass – plastic stems are prohibited.

B. Stalls shall be field installed tile. Refer to architectural documents for details. Separate floor drain shall be provided for sanitary waste drainage. Refer to 221319 Sanitary Waste and Vent Piping Specialties and plumbing fixture schedule on drawing set for floor drain specifications.

2.13. ICE MAKER UTILITY BOX

A. Appliance(s) shall be provided by others. The contractor shall provide final connections to the fixture.

B. Recessed valve box: Powder-coated steel preformed rough-in box with brass quarter-turn, hammer arrester valves, and slip-in finishing cover.

2.14. WASHER UTILITY BOX

A. Appliance(s) shall be provided by others. The contractor shall provide final connections to the fixture.

B. Recessed valve box: Powder-coated steel preformed rough-in box with brass quarter-turn, hammer arrester valves, and slip-in finishing cover.

2.15. CONDENSATE DRAIN BOX

A. Appliance(s) shall be provided by others. The contractor shall provide final connections to the fixture.

B. Recessed valve box: Powder-coated steel preformed rough-in box with optional funnel and louvered face plate / trim cover.

PART 3 - EXECUTION

3.1. EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.

B. Examine walls and floors for suitable conditions where water closets will be installed.

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

3.2. INSTALLATION

A. Water-Closet Installation:

1. Install level and plumb.

2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.

3. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.

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.

3. Install supports, affixed to building substrate, for wall-hung urinals.

C. Flushometer Valve Installation:

1. Install flushometer-valve, water-supply fitting on each supply to each water closet and urinal.

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 fresh batteries in battery-powered, electronic-sensor mechanisms.

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.

3. Comply with escutcheon requirements specified in Section 220100.

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.

3.3. CONNECTIONS

A. Connect fixtures with water supplies and soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116.

C. Comply with sanitary waste piping requirements specified in Section 221316.

3.4. ADJUSTING

A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.

B. Adjust water pressure at flushometer valves to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5. CLEANING AND PROTECTION

A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed water closets and fittings.

C. Do not allow use of water closets, urinals, or sinks for temporary facilities unless approved in writing by Owner.

END OF SECTION 224000

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SECTION 230100 – HVAC GENERAL WORK REQUIREMENTS

PART 1 - GENERAL

1.1. SUMMARY

A. This section includes general requirements and information for Division 23 work.

1.2. DEFINITIONS

A. Owner Acceptance for Beneficial Occupancy: Work that is judged by the Engineer to be substantially complete, accepted to be safe for use by the Authority Having Jurisdiction (AHJ), and accepted by the Owner. Acceptance comes with an agreement the Engineer's written punchlist of outstanding items will be completed to fulfill the contractual obligations.

B. Full Owner Occupancy: Owner will occupy the site and existing building during entire construction period.

C. Partial Owner Occupancy: Owner may occupy completed areas of building before Owner Acceptance.

D. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

E. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

F. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

G. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

H. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

I. Provide: Contractor shall furnish and install materials, equipment or fixtures as indicated.

J. Install Items Furnished by Owner or Others: Contractor shall receive shipment, store, install and verify materials, equipment or fixtures selected and purchased outside of the prime construction contract as indicated.

K. Furnish Items to Owner or Others: Contractor shall purchase and deliver materials, equipment or fixtures for installation by others as indicated.

1.3. SUBMITTALS

A. Qualification Submittals:

1. Welding certificates.

B. Construction Submittals:

1. Manufacturer startup, operation and maintenance checklists for all equipment and devices included in Division 23 specifications in a single submittal package for review prior to equipment startup.

C. Closeout Submittals:

1. Manufacturer startup, operation and maintenance reports with completed checklists signed by the involved technicians and the Mechanical Contractor's witnessing superintendent.

1.4. INSPECTIONS

A. Contractor shall be responsible for obtaining all inspections from regulatory agencies having jurisdiction over the project. These inspections include but are not limited to: NC Department of Labor - NCDOL Boiler Safety Bureau for boilers and pressure vessels, NC Department of Insurance NCDOI, and other Local, State, and Federal inspection authorities as applicable.

1.5. QUALITY ASSURANCE

A. Welding Qualifications:

1. Installer Qualifications: Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

2. AWS D1.1, "Structural Welding Code--Steel."

3. AWS D1.2, "Structural Welding Code--Aluminum."

4. AWS D1.3, "Structural Welding Code--Sheet Steel."

5. AWS D1.4, "Structural Welding Code--Reinforcing Steel."

6. ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Roof Warranties: All work on roofs shall comply with the roof manufacturer's warranty requirements. For work on existing roofs, obtain a copy of the Owner's roof warranty prior to the start of work.

C. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

D. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

E. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

1.6. WARRANTY

A. Project Warranty: All work performed and all materials installed in Division 23 shall be warrantied by the Contractor for 1 year from the Owner's written acceptance of Owner Acceptance. The warranty shall include all labor and parts. The Contractor shall be on site within 48 hours of Owner notifications.

1. This warranty does not waive the Owner's obligation to provide routine maintenance. Routine maintenance includes maintenance recommended by each equipment manufacturer and industry standard requirements for overall systems as documented in the project's Operation and Maintenance Manuals. Replacement of wear items such as filters, belts, etc. are not included in the warranty unless they are incidental to other warranty work being performed. Failures due to the lack of routine maintenance are the responsibility of the Owner.

2. Equipment manufacturer's disclaimers and limitations on product warranties do not relieve the Contractor of the obligations of the Project Warranty.

3. Extended or special warranties defined in other sections shall be in addition to, and run concurrently with, the Project Warranty.

1.7. PROJECT DOCUMENTS

A. Project Documents: Division 23 project documents are diagrammatic in nature and intended to represent complete and functioning systems. If any aspect of the work is undefined or unclear, submit your questions in writing prior to the final addendum deadline as defined in the specifications and/or at the pre-bid conference. If any aspect of the work is undefined or unclear after the final addendum, include the cost for the highest quality solution. The contractor is encouraged to thoroughly review the contract documents and site conditions prior to bidding.

B. Basis of Design Manufacturers: Manufacturer names and model numbers of equipment and devices noted on drawings and in equipment schedules shall be considered the Engineer's basis of design. Proposed changes to the basis of design shall be submitted to the Engineer for review and approval. The submittal shall include a description of all changes necessary to implement the substitution, including but not limited to plumbing, mechanical and electrical connections; dimensions, weights and structural supporting structure; layout changes necessary to maintain clearances; and acoustical treatments. All changes required to implement a substitution is the responsibility of Contractor at no added cost to the Owner.

C. Listed Manufacturers: Manufacturers listed in the Division 23 specification sections and on drawings must meet all the requirements of the project documents. Listed manufacturers that do not meet the requirements will not be accepted. The manufacturer listing does not result in an automatic approval. In addition to construction and performance requirements, the proposed equipment must meet the indicated physical dimension, weight, acoustic, power, controls, and plumbing limitations of the

project. Verify existing conditions in the field, when applicable, and proposed conditions prior to submitting equipment for Engineer review. When full project coordination drawings are not required, generate coordination drawings to the level of detail necessary to determine if the proposed equipment will comply with the project documents and manufacturer recommended maintenance clearances.

1. If a manufacturer's equipment does not meet the physical dimension, weight, acoustic, power, controls and plumbing limitations of the project, a change order proposal may be submitted for the Owner's and Engineer's consideration. The proposal shall include all changes, including other trades, required and a reduction in cost to accept the non-conforming equipment. The base bid shall include equipment that fully meets the design requirements at no additional cost.

1.8. COMMISSIONING PROCESS

A. General: The Owner's Commissioning Agent (CxA) will lead a commissioning team made up of owner and contractor representatives. Refer to Section 019113 for more information.

1. Members Appointed by Contractor(s): Individuals, each having the authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated action. The commissioning team shall consist of, but not be limited to, representatives of each Contractor, including Project superintendent and subcontractors, installers, suppliers, and specialists deemed appropriate by the CxA.

2. Owner's CxA: The designated person, company, or entity that plans, schedules, and coordinates the commissioning team to implement the commissioning process. Owner will engage the CxA under a separate contract.

3. Owner's Facility Representatives: Facility user and operation and maintenance personnel.

4. Engineers: Design professional.

B. Contractor's Responsibilities:

1. Each Contractor shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:

a. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.

b. Cooperate with the CxA for resolution of issues recorded in the Issues Log.

c. Attend commissioning team meetings held on a weekly basis.

d. Integrate and coordinate commissioning process activities with construction schedule.

e. Review and accept construction checklists provided by the CxA.

f. Complete construction checklists as Work is completed and provide to the Commissioning Authority on a weekly basis.

g. Review and accept commissioning process test procedures provided by the Commissioning Authority.

h. Complete commissioning process test procedures.

C. CxA's Responsibilities:

1. Organize and lead the commissioning team.

2. Provide commissioning plan.

3. Convene commissioning team meetings.

4. Provide Project-specific construction checklists and commissioning process test procedures.

5. Verify the execution of commissioning process activities using random sampling. The sampling rate may vary from 1 to 100 percent. Verification will include, but is not limited to, equipment submittals, construction checklists, training, operating and maintenance data, tests, and test reports to verify compliance with the OPR. When a random sample does not meet the requirement, the CxA will report the failure in the Issues Log.

6. Prepare and maintain the Issues Log.

7. Prepare and maintain completed construction checklist log.

8. Witness systems, assemblies, equipment, and component startup.

9. Compile test data, inspection reports, and certificates; include them in the systems manual and commissioning process report.

1.9. COORDINATION

A. Maintenance Access: Install equipment and devices in such a manner to be readily accessible for testing, adjusting, balancing, inspection and maintenance. All concealed equipment and devices, including but not limited to equipment, valves, dampers, actuators, sensors, gauges, test ports, filter housings, coils, etc., shall be installed above accessible ceilings, within accessible rooms or chases or within normally inaccessible construction with access doors. All access doors are not shown in the project drawings. All access doors shall be coordinated with the Engineer prior to the installation of the equipment or device. Equipment and/or devices not coordinated prior to installation, as judged by the Engineer, shall be removed and reinstalled at no added cost.

B. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

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

D. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces.

1.10. SPECIAL TESTS AND INSPECTIONS

A. Special Tests and Inspections: Owner will engage a qualified Special Inspector to conduct special tests and inspections required by authorities having jurisdiction as the responsibility of Owner as indicated in the Statement of Special Inspections.

B. Special Inspector: The Special Inspector's scope of work will be defined by the Owner. In general, they will verify the materials have been installed properly and completely; notify the Owner, Engineer, and Contractor of deficiencies; test corrected work, and submit a certified report of their procedures and findings.

1. Coordinate observations and testing with the Special Inspector and correct noted deficiencies.

C. Mechanical System Special Inspections:

1. Firestopping systems in Section 230500.

1.11. VOC CONTENTS

A. Low Volatile Organic Compounds (VOC) Requirements: All adhesives, mastics, sealants and compounds factory or field applied that are installed indoors and all paint field applied shall be certified as low VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

1. Adhesives: 50 g/L or less, except 80 g/L or less for calcium silicate and mineral fiber insulation and 30 g/L or less for metal-to-metal adhesives.

2. Mastics: 50 g/L or less.

3. Sealants: 250 g/L or less for duct sealants and 420 g/L or less for equipment insulation joint sealants.

4. Compounds: 490 g/L or less for CPVC welding compounds and 510 g/L or less for PVC welding compounds.

5. Paints: 50 g/L or less for flat paints and primers and 150 g/L or less for non-flat paints.

PART 2 - PRODUCTS

2.1. PAINTS AND PRIMERS

A. General: Provide primers and paints designed for the intended applications. All primers and paints used indoors shall be low-odor and low VOC content type.

B. Primers:

1. Metal Applications: Water-based rust-inhibitive primer.

2. Aluminum Applications: Quick-drying primer for aluminum.

3. Wood Applications: Latex-based wood primer.

4. Interior Applications: Interior latex primer/sealer.

C. Paints:

1. Interior Applications: High-performance interior latex.

2. Exterior Applications: Exterior latex.

3. Match gloss level to adjacent finishes when applicable. Flat gloss level for all other applications, unless otherwise indicated.

2.2. CONCRETE MATERIALS

A. Concrete: Use the following unless otherwise indicated:

1. Equipment Housekeeping Pads: Light-weight aggregate with 3000 psi, 28-day minimum compressive strength.

2. Miscellaneous Uses: Medium-weight aggregate with 4000 psi, 28-day minimum compressive strength.

B. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.

C. Welded Wire Steel Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.

2.3. GROUT

A. Description: ASTM C 1107, Grade B, non-shrink and nonmetallic, dry hydraulic-cement grout.

B. Characteristics: Post-hardening, volume-adjusting, non-staining, noncorrosive, nongaseous, and recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.4. PATCHING MATERIALS

A. General: Comply with requirements specified in other Sections.

B. In-Place Materials: Use materials identical to in-place materials. For exposed surfaces, use materials that visually match in-place adjacent surfaces to the fullest extent possible.

1. If identical materials are unavailable or cannot be used, use materials that, when installed, will match the visual and functional performance of in-place materials.

2.5. ESCUTCHEONS AND FLOOR PLATES

A. Escutcheons:

1. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

2. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

3. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.

B. Floor Plates:

1. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

2. Split-Casting Floor Plates: Cast brass with concealed hinge.

2.6. ACCESS DOORS AND FRAMES, WALLS AND CEILINGS

A. Refer to Architectural documents for access door requirements.

PART 3 - EXECUTION

3.1. DOCUMENTATION OF PROJECT CONDITIONS

A. Project Conditions: Document in digital-format photos and video the existing project conditions and continue to document the conditions as the project progresses. Owner claims of contractor damage will be judged by the documented conditions.

3.2. OPERATION AND MAINTENANCE MANUALS

A. The contractors shall deliver one complete set of bookmarked manuals in electronic PDF format of all operation and maintenance manuals to the Owner through the Designer, two (2) weeks before the pre-final inspection is held. The manuals shall be bookmarked to a minimum of one level – ie: each major piece of equipment (chiller, boiler switchboard, water closet, water heater, etc.) or document category (warranties, parts list, contact information, etc.) The manuals shall be delivered by one of the following:

1. Downloadable file from online service

B. Manuals shall include the following (at a minimum):

1. Index and page numbers
2. Certificate of Owner Acceptance
3. Summary sheet of warranties with dates noted and a copy of all warranties
4. List of all subcontractors and suppliers with names, addresses, and phone numbers
5. Special Inspection Reports
6. Certified Test and Balance Report
7. Complete start-up, operation, and shutdown procedures for each system including sequence of events, locations of switches, emergency procedures, and any other critical items.
8. Lubrication schedules and types of lubricants
9. Complete set of all submittal data and current shop drawings (including 3rd party generated shop drawings) and equipment description showing all capacities and other operation conditions.
10. Equipment summary showing all capacities and ratings (HP, Tons, kW, filter size, etc.).

3.3. OPERATION OF HVAC SYSTEMS DURING CONSTRUCTION

A. The Prime Contractor shall provide temporary heating, ventilation and air-conditioning as needed for the construction process. Use of the permanent HVAC is prohibited.

B. Permanent HVAC systems and components may only be operated for verification, testing, adjusting and balancing.

C. Owner/Engineer shall approve project conditions prior to system start-ups. Request start-up inspection minimum of 2 weeks prior to proposed start. Proposed start shall be coordinated with Owner's/Engineer's schedule.

D. Air System Temporary Operation: Systems shall only be operated when the building is completely enclosed, is clean and there are no dust or fume creating activities being performed.

1. Filtration: Prior to starting air systems, verify clean filters are installed in all air system equipment and clean temporary filter media is installed on all air intakes. Replace temporary filters on a regular basis. Provide minimum MERV-8 temporary filter media and comply with Section 234100. Replace all filters with new prior to Owner acceptance.
2. Air System Equipment Cleaning: Clean inside of air system equipment and install filters.
3. Air Handling Unit Control: The goal of construction conditioning is to remove excessive humidity to allow the installation of finishes. It is not to meet building design temperature.
    a. Air handlers should be started initially at 100-percent outside air. Outside air intakes shall have a double layer of blue roll filter media, either at the outside air intake louvers or directly inside the unit prior to prefilters. If outside air intakes are going to be exposed to dust and dirt from site construction, consideration should be made to temporarily relocate intake by ducting to an elevation where the intake is protected from dirt and dust. Roll filter media should be

periodically monitored for build-up and replaced as necessary. Do not operate unit while changing filters.

b. If systems do not have 100-percent outside air capability and return duct must be utilized, all return openings must be filtered to prevent contaminating the duct system and equipment.

c. When using return air, do not close outside air damper completely. Balance outside air flow to 10 to 20-percent of total flow to maintain positive pressure in the building.

E. Hydronic System Temporary Operation: Systems shall only be operated when the spaces where pumps, motors and variable speed drives are located are clean and there are no dust or fume creating activities being performed.

1. Cleaning: Prior to starting hydronic systems, verify motor housings are clean by using compressed air to blow out any dust and debris. Clean them on a regular basis during system operation.

F. Owner/Engineer must approve operation of the permanent HVAC systems for use at Owner Acceptance.

3.4. WELDING AND BRAZING

A. Medium and High Pressure Piping (Above 15 psig):

1. Fabrication:

a. Heating water piping systems shall be fabricated, assembled and welded in accordance with ASME B31.1, and Power Piping Codes PFI ES 1, PFI ES 3, PFI ES 7, PFI ES 21, PFI ES 31, PFI ES 35, and PFI TB1 of the Piping Fabrication Institute's companion code requirements.

b. Other high pressure piping systems shall be fabricated, assembled and welded/brazed/ soldered in accordance with ASME B31.3, and Power Piping Codes PFI ES 1, PFI ES 3, PFI ES 7, PFI ES 21, PFI ES 31, PFI ES 35, and PFI TB1 of the Piping Fabrication Institute's companion code requirements.

c. Refrigeration piping systems shall be fabricated, assembled and welded/brazed in accordance with the ASME B31.5.

2. Non-Destructive Inspection and Testing: All pipe welds shall be tested by a qualified, Engineer approved, testing agency at the expense of the Contractor.

B. Low Pressure Piping (15 psig and lower):

1. Fabrication:

a. Copper make-up water and drainage piping systems shall be fabricated, assembled and soldered in accordance with ASTM B828.

b. Other low pressure piping systems shall be fabricated, assembled and welded/brazed in accordance with the ASME B31.9.

2. Non-Destructive Inspection and Testing: Engineer shall visually inspect pipe welds. Based on visual inspections, upon order of the Engineer, non-destructive testing of selected pipe welds shall

be performed by a qualified testing agency, at the expense of the Contractor, using one of the following methods selected by the Engineer. The welds inspected shall be selected randomly, but the selection shall include an examination of welds made by each welding operator or welder.

C. Testing Methods:

1. Radiographic testing in accordance with ASTM E 94:

a. Make identification of defects by comparing radiographs to reference radiographs in ASTM E 390.

b. Film shall positively and properly identify as to member being inspected, location of weld, and location of film on weld.

c. Stamp identification on steel so film may be easily identified and matched to identification mark.

2. Ultrasonic testing in accordance with ASTM E 164:

a. Size of defects will be determined by relating amplitude of oscilloscope traces to hole in ASTM reference weldment.

b. Diameter of reference holes shall be 3/32-inch.

c. Weld defects which are cause for rejection include cracks, lack of fusion, incomplete penetration, porosity, or slag inclusions which produce reflections equal to or greater than 80 percent of reference hole reflection and have linear dimensions as indicated by transducer movement exceeding 1/4-inch for material thickness up to and including 3/4-inch.

D. Correction of Defective Welds: If random testing reveals that any welds fail to meet minimum quality requirements, an additional 10 percent of the welds in that same group shall be inspected at the Contractor's expense. If all of the additional welds inspected meet the quality requirements, the entire group of welds represented shall be accepted and the defective welds shall be repaired. If any of the additional welds inspected also fail to meet the quality requirements, that entire group of welds shall be rejected. At the Contractor's option, the rejected welds shall be removed and the joints re-welded or the rejected welds shall be 100 percent tested as hereinbefore specified and all defective weld areas removed and re-welded.

1. If the initial testing reveals any deficient welds, then all initial and follow-up testing and all work required to replace the deficient welds shall be at the Contractor’s expense.

2. If the initial testing does not reveal any deficiencies, then the initial testing shall be at the Owner’s expense.

3.5. PAINTING

A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates indicated.

B. Clean substrates of substances that could impair bond of paints, including dirt, oil, grease, and incompatible paints and encapsulants.

1. Remove incompatible primers and re-prime substrate with compatible primers as required to produce paint systems indicated.

C. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

D. Painting of Division 23 Work: Paint items exposed in equipment rooms and occupied spaces including, but not limited to, the following:

1. Visible portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets.

2. Duct, equipment, and pipe insulation having cotton, canvas or metal insulation covering or other paintable jacket material as required by Section 230553 and elsewhere as indicated.

3. Mechanical equipment that is indicated to have a factory-primed finish for field painting.

4. Equipment pads as indicated.

E. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Engineer, and leave in an undamaged condition.

F. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces. Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6. CONCRETE

A. Design, construct, erect, brace, and maintain formwork according to ACI 301.

B. Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

C. Comply with ACI 301 for measuring, batching, mixing, transporting, and placing concrete.

D. Equipment Concrete Bases: Housekeeping pads shall match the indicated dimensions but not be less than required to extend 4-inches beyond the equipment footprint in each direction and have chamfered edges.

1. Concrete Base Depths:

a. Air Handling Units and Chillers: Minimum 6-inches thick, unless otherwise indicated.

b. HVAC Equipment: Minimum 4-inches thick, unless otherwise indicated.

2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.

3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.

4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

5. Install anchor bolts to elevations required for proper attachment to supported equipment.

6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.7. GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.8. WALL, FLOOR AND ROOF OPENINGS

A. Exterior and interior wall, floor and roof openings made for duct, piping and conduit penetrations shall maintain the building’s structural integrity. Install penetration sleeves, framing and lintels in accordance with the structural engineer.

3.9. REPAIR AND PATCHING

A. Repair damage created during the construction process. Repair quality shall be equal to or better than original condition as judged by the Architect/Engineer.

B. Patch wall, floor and roof openings created by removal of mechanical system items during the construction process. Patch and finish with materials consistent with adjacent finishes and materials.

1. Openings in fire /smoke rated assemblies shall be patched per UL-listed detail.

C. Identify and document existing building damage and openings in walls, floor and roof that are outside the project scope prior to the start of work. Report them promptly to the Architect/Engineer.

3.10. ACCESS DOOR INSTALLATION

A. Coordinate the need, type, and exact location of each access door with Architect/Engineer prior to installation.

B. Center wall and ceiling access doors on duct access doors, valve centers, junction boxes, etc. to provide the best access to inspect, operate, and maintain the associated mechanical and electrical devices.

C. Install wall and ceiling access doors level and square to building surfaces. Comply with manufacturer's written instructions.

D. Install access doors such that their door swings are not blocked from opening fully and they open in the direction that provides the best access for the user.

E. Adjust doors and hardware for proper installation.

F. Touch-up door finishes with factory-provided paint as needed prior to completion.

G. Verify fire and smoke-rated door labels have not been painted over in the field.

H. Label wall and ceiling access doors with clear plastic ceiling tags in compliance with Section 23 05 53.

3.11. PIPING SYSTEM INSTALLATION GENERAL REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs. Refer to Section 230517 for more information about sleeves and sleeve seals.

M. Verify final equipment locations for roughing-in.

N. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

O. Piping Connections: Make piping connections according to the following unless otherwise indicated:

1. Install unions, in piping 2-inches NPS and smaller, adjacent to each valve and at final connection to each piece of equipment.

2. Install flanges, in piping 2-1/2 inches NPS and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.12. ESCUTCHEONS AND FLOOR PLATES INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with inside diameter to closely fit around pipe, tube, and insulation of piping and with outside diameter that completely covers opening.

1. New Piping: Install one-piece cast-brass type for new piping installations. Install deep-pattern type where piping sleeve protrudes from the floor or wall.

2. Existing Piping: Install split-casting brass type for existing piping installations.

C. Install floor plates with inside diameter to closely fit around pipe, tube, and insulation of piping and with outside diameter that completely covers opening.

1. New Piping: One-piece, floor-plate type.

D. Replace broken and damaged escutcheons and floor plates using new materials.

3.13. EQUIPMENT INSTALLATION GENERAL REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.14. ADDITIONAL CONSTRUCTION PROCEDURES

A. General Requirements: In addition to the requirements of Division 1 and individual Division 23 sections, the Contractor shall comply with the following requirements during project construction:

1. Bidding: Review the requirements in the entire set of bid documents. Review the Project Documents paragraphs in Part 1 of this section. Submit clarification questions in compliance with Division 1 and Division 23.

2. Submittals: Submit delegated design, qualification, product, construction and close-out submittals required in each Division 23 section. Utilize the Submittal List in Section 230110 to verify each submittal has been submitted and reviewed prior to the installation of related equipment and materials.

3. Reference Documents: Maintain a hard copy set of Division 23 bid documents and submittals for reference in the on-site project office. Mark documents to record installed conditions and tested duct and piping.

    a. Duct and Pipe Pressure and Leakage Testing: Upon successful completion of testing each section of duct and pipe, number, highlight, date and initial the tested sections. The section numbers shall match in the testing report. Each tested section shall be initialed by an appropriate representative from the Contractor and Owner / Commissioning Agent or Engineer.

    b. Life-Safety Dampers: Successfully tested life-safety dampers shall be highlighted and initialed by an appropriate representative from the Contractor and Owner / Commissioning Agent or Engineer.

4. Stored Material Verification: In coordination with each monthly Owner Construction Coordination Meeting, provide a copy of the month's proposed Payment Application and access to all equipment or material stored in an off-site insured and bonded warehouse for verification meeting the requirements of Division 1. Payment Applications with unverified off-site stored equipment and materials will not be approved.

5. Pre-Installation and Testing Meetings: Schedule Pre-Installation Meetings required in Division 23 sections with the Owner / Commissioning Agent and Engineer.

6. Equipment Start-Up: Schedule major equipment start-up procedures with the Owner / Commissioning Agent and Engineer.

END OF SECTION 230100

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SECTION 230110 – HVAC SUBMITTAL LIST

PART 1 - GENERAL

1.1. SUMMARY

A. This section is a supplement to the Division 23 and 25 specification sections. Submittal descriptions in this section are not intended to alter the requirements defined in other sections.

1.2. SUBMITTAL REQUIREMENTS

A. Conform to format defined in Division 1 and content defined in Division 23.

B. Submittals will be rejected without review if they:

1. Do not conform with most recent version of contract documents.
2. Do not have delegated design documents signed and sealed by a P.E. in the state of the project.
3. Were not routed through the proper channels.
4. Do not indicate review by Construction Manager / General Contractor.
5. Do not indicate selected options.

1.3. HVAC SUBMITTAL LIST

SUBMITTAL SCHEDULE	
PRE-CONSTRUCTION	
SECTION	DESCRIPTION
23 01 00	WELDING QUALIFICATIONS
23 04 00	COORDINATION DRAWINGS
23 05 00	FIRESTOPPING MATERIALS
23 05 11	ELECTRICAL DEVICES - ENCLOSURES, DISCONNECTS & STARTERS
23 05 14	VARIABLE SPEED CONTROLLERS
23 05 16	EXPANSION DEVICES
23 05 16	DELEGATED DESIGN FOR PIPE ANCHORS AND GUIDES
23 05 17	SLEEVE SEAL PRODUCTS
23 05 19	GAUGES AND DEVICES FOR PIPING SYSTEMS
23 05 33	HEAT TRACING
23 05 48	VIBRATION CONTROL DELEGATED DESIGN
23 05 48	VIBRATION CONTROL DEVICES
23 05 53	IDENTIFICATION DEVICES

23 05 93	T/A/B QUALIFICATIONS
23 05 93	T/A/B CONTRACT DOCUMENT EXAMINATION REPORT
23 05 93	T/A/B PROCEDURE PLAN
23 05 93	T/A/B INSTRUMENT CALIBRATION REPORTS
23 07 13	DUCT AND DUCTED EQUIPMENT INSULATION
23 07 19	PIPING AND PIPED EQUIPMENT INSULATION
23 21 13	HYDRONIC PIPING AND FITTINGS
23 21 16	HYDRONIC PIPING SPECIALTIES
23 21 19	HYDRONIC GENERAL PURPOSE VALVES
23 21 19	HYDRONIC BALANCING VALVES
23 21 23	HYDRONIC PUMPS
23 21 33	UNDERGROUND PIPING DELEGATED DESIGN
23 23 00	REFRIGERANT PIPING, VALVES AND FITTINGS
23 25 00	WATER TREATMENT SYSTEMS
23 25 00	WATER TREATMENT PROVIDER QUALIFICATIONS
23 31 13	DUCT SHOP DRAWINGS
23 31 13	DUCT SCHEDULE AND MATERIALS
23 33 00	DUCT ACCESSORIES
23 34 00	FANS
23 36 00	AIR TERMINAL UNITS
23 37 13	DIFFUSERS, GRILLES AND REGISTERS
23 37 23	GRAVITY VENTILATORS
23 41 00	PARTICULATE AIR FILTRATION - STANDARD EFFICIENCY
23 41 33	PARTICULATE AIR FILTRATION - HIGH EFFICIENCY
23 51 00	BREECHINGS, CHIMNEYS AND STACKS
23 52 16	CONDENSING BOILERS
23 64 26	AIR-COOLED CHILLERS
23 72 00	AIR-TO-AIR ENERGY RECOVERY EQUIPMENT
23 73 11	BLOWER COIL UNITS
23 73 16	MODULAR AIR HANDLING UNITS
23 81 16	DUCTLESS MINI-SPLIT SYSTEMS
23 82 39	UNIT HEATERS
23 90 00	BAS CONTROL SYSTEM PROTOCOL CERTIFICATES
23 90 00	BAS CONTROL SYSTEM SHOP DRAWINGS
23 90 00	BAS CONTROL SYSTEM PRODUCT DATA

23 90 00	BAS CONTROL DAMPERS AND ACTUATORS
23 90 00	BAS CONTROL VALVES AND ACTUATORS
23 90 10	BAS INSTRUMENTATION DEVICES
23 92 10	BAS ENERGY AND FLOW METERS
DURING CONSTRUCTION	
SECTION	DESCRIPTION
23 01 00	STARTUP, OPERATION AND MAINTENANCE CHECKLISTS
23 02 00	INSTRUCTION PROGRAM
23 03 00	EXCAVATION SUPPORT AND PROTECTION PROCEDURES
23 05 55	FLUSHING AND TESTING PLAN
23 05 55	FLUSHING AND TESTING FIELD REPORTS AND SUMMARY REPORT
23 05 93	T/A/B INSTRUMENT CALIBRATION REPORTS
23 05 93	T/A/B REPORTS - HVAC AND PLUMBING SYSTEMS
23 05 93	T/A/B REPORTS - SOUND TESTING RESULTS
23 05 93	T/A/B REPORTS - VIBRATION TEST RESULTS
23 05 93	T/A/B REPORTS - BAS CONTROLS VERIFICATION
23 05 93	T/A/B COMMISSIONING AGENT CERTIFICATION
23 31 13	DUCT LEAKAGE TEST REPORTS
23 33 00	LIFE-SAFETY DAMPER TESTING REPORTS
VARIOUS	EQUIPMENT START-UP REPORTS
23 90 00	BAS SYSTEM CHECKOUT PROCEDURES
CONSTRUCTION CLOSE OUT	
SECTION	DESCRIPTION
23 01 00	PROJECT WARRANTY
23 01 00	OPERATION AND MAINTENANCE MANUALS
23 01 00	STARTUP, OPERATION AND MAINTENANCE REPORT
23 02 00	DEMONSTRATION AND TRAINING MATERIALS
23 05 93	T/A/B FINAL REPORT
23 03 00	PHOTOGRAPHIC DOCUMENTATION OF UNDERGROUND UTILITIES
VARIOUS	AS-BUILT RECORD DRAWINGS
VARIOUS	EXTRA MATERIALS PROOFS OF RECEIPT

PART 2 - PRODUCTS (not used)

PART 3 - EXECUTION (not used)

END OF SECTION 230110

SECTION 230200 – HVAC SYSTEMS OWNER TRAINING

PART 1 - GENERAL

1.1. SUMMARY

A. This section includes general requirements for the owner's demonstration and training of Division 23 systems and equipment.

1.2. SUBMITTALS

A. Construction Submittals:

1. Instruction Program: Submit outline of instructional program for demonstration and training including proposed dates, times, lengths of instruction times, instructor's name and instructor's qualifications.

1.3. QUALITY INSURANCE

A. Facilitator Qualifications: A firm or individual experienced in training or educating maintenance personnel in a training program similar in content and extent to that indicated for this Project, and whose work has resulted in training or education with a record of successful learning performance.

B. Instructor Qualifications: A factory-authorized service representative experienced in operation and maintenance procedures and training.

C. Pre-Instruction Conference: Conduct conference at the project site. Review methods and procedures related to demonstration and training.

D. Coordinate content of training modules with content of approved emergency, operation, and maintenance manuals. Do not submit instruction program until operation and maintenance data has been reviewed and approved by Architect.

PART 2 - PRODUCTS

2.1. INSTRUCTION PROGRAM

A. Program Structure: Develop an instruction program that includes individual training modules for each system and equipment not part of a system, as required by individual Specification Sections, and as follows:

1. HVAC Control Systems

2. Flow and Energy Meters

3. Motor Starters and Disconnect Switches

4. Variable Speed Drives
5. Life-Safety Dampers
6. Fans, Supply, Return, Relief and Exhaust
7. Terminal Units
8. Air Handling Units, Packaged and Modular
9. Blower Coil Units
10. Unit Heaters
11. Ductless Mini-Split System Units
12. Heating and Cooling Coils
13. Energy Recovery Systems
14. Pumps
15. Boilers
16. Chillers
17. Air Filtration
18. Water Treatment

B. Training Modules: Develop a learning objective and teaching outline for each module. Include a description of specific skills and knowledge that participant is expected to master. For each module, include instruction for the following:

1. Basis of System Design, Operational Requirements and Criteria: Include system and equipment descriptions, operating standards, regulatory requirements, equipment function, operating characteristics, limiting conditions, and performance curves.
2. Documentation: Review emergency, operations, and maintenance manuals; Project Record Documents; identification systems; warranties and bonds; and maintenance service agreements.
3. Emergencies: Include instructions on stopping; shutdown instructions; operating instructions for conditions outside normal operating limits; instructions on meaning of warnings, trouble indications, and error messages; and required sequences for electric or electronic systems.

4. Operations: Include startup, control, and safety procedures; stopping and normal shutdown instructions; routine, normal, seasonal, and weekend operating instructions; operating procedures for emergencies and equipment failure; and required sequences for electric or electronic systems.

5. Adjustments: Include alignments and checking, noise, vibration, economy, and efficiency adjustments.

6. Troubleshooting: Include diagnostic instructions and test and inspection procedures.

7. Maintenance: Include inspection procedures, types of cleaning agents, methods of cleaning, procedures for preventive and routine maintenance, and instruction on use of special tools.

8. Repairs: Include diagnosis, repair, and disassembly instructions; instructions for identifying parts; and review of spare parts needed for operation and maintenance.

PART 3 - EXECUTION

3.1. GENERAL REQUIREMENTS

A. Facilitator: Engage a qualified facilitator to prepare instruction program and training modules, to coordinate instructors, and to coordinate between Contractor and Owner for number of participants, instruction times, and location.

B. Engage qualified instructors to instruct Owner's personnel to adjust, operate, and maintain systems, subsystems, and equipment not part of a system.

C. Scheduling: Provide instruction at mutually agreed on times. For equipment that requires seasonal operation, provide similar instruction at start of each season.

1. Schedule training with Owner with at least 30 days' advance notice.

D. Instruction Duration: Instructional time shall be no less than two (2) 8-hour days with an hour break for lunch, 8:00 am – 5:00 pm.

E. Document training attendance for each session.

END OF SECTION 230200

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SECTION 230300 – HVAC UNDERGROUND UTILITIES WORK REQUIREMENTS

PART 1 - GENERAL

1.1. SUMMARY

A. This section includes excavation, backfill, piped utility demolition, tree protection, temporary erosion and sedimentation control, grout and flowable fill of Division 23 systems and equipment.

B. In projects with Division 31-33 specifications, this section is intended to supplement those requirements. Where there are conflicts, the strictest requirement shall apply.

1.2. SUBMITTALS

A. Delegated Design Submittals: Design of excavation support and protection methods and systems.

B. Construction Submittals:

1. Instruction Program: Submit outline of instructional program for demonstration and training including proposed dates, times, lengths of instruction times, instructor's name and instructor's qualifications.

C. Close-Out Submittals:

1. Record Drawings: Locating and identifying HVAC utilities within the project area, including sizes, dimensions, elevations, building and manhole entrances, crossing utilities, etc.

a. Photographic Documentation: Include photographs of original and final conditions including utilities while exposed in trenches. Key the photos to the record drawings to provide visual documentation of the underground conditions and locations of the utilities.

1.3. PRE-INSTALLATION MEETING

A. Pre-Installation Conference: Conduct conference at project site to review the following:

1. Existing utilities and subsurface conditions.

2. Coordination of utility interruptions.

3. Building and tree protection.

4. Proposed excavations and excavation support and protection strategy.

5. Proposed vehicle and pedestrian traffic plans.

6. Proposed flushing and testing plan.

1.4. FIELD CONDITIONS

A. Interruption of Existing Utilities: Do not interrupt any utility serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:

1. Notify Owner/Engineer no fewer than 14 days in advance of proposed interruption of utility.

2. Do not proceed with interruption of utility without Owner's/Engineer's written permission.

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 a geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by a geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from the data.

1. Make additional test borings and conduct other exploratory operations necessary for excavation support and protection according to the performance requirements.

2. The geotechnical report is referenced elsewhere in Project Manual.

C. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

PART 2 - PRODUCTS

2.1. PERFORMANCE REQUIREMENTS

A. Provide, monitor and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting earth and hydrostatic pressures and superimposed and construction loads.

1. Contractor Design: Design excavation support and protection system, including comprehensive engineering analysis by a qualified professional engineer.

2. Prevent surface water from entering excavations by grading, dikes, or other means.

3. Install excavation support and protection systems without damaging existing buildings, structures, and site improvements adjacent to excavation.

4. Continuously monitor vibrations, settlements, and movements to ensure stability of excavations and constructed slopes and to ensure that damage to permanent structures is prevented.

2.2. MATERIALS

A. General: Provide materials that are either new or in serviceable condition.

B. Structural Steel: ASTM A 36/A 36M, ASTM A 690/A 690M, or ASTM A 992/A 992M.

C. Steel Sheet Piling: ASTM A 328/A 328M, ASTM A 572/A 572M, or ASTM A 690/A 690M; with continuous interlocks.

D. Corners: Site-fabricated mechanical interlock.

E. Wood Lagging: Lumber, mixed hardwood, nominal rough thickness of size and strength required for application.

F. Cast-in-Place Concrete: ACI 301, of compressive strength required for application.

G. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.

H. Tiebacks: Steel bars, ASTM A 722/A 722M.

2.3. SOIL MATERIALS

A. Satisfactory Soils: ASTM D 2487 Soil Classification Groups GW, GP, GM, SW, SP, and SM, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

1. Obtain approved clean fill soil material off-site when satisfactory soil materials are not available on-site.

B. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487 or a combination of these groups.

1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

C. Sub-Base Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.

D. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 95 percent passing a 1-1/2-inch sieve and not more than 8 percent passing a No. 200 sieve.

E. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.

F. Drainage Course: Narrowly graded mixture of washed crushed stone or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and 0 to 5 percent passing a No. 8 sieve.

G. Sand: ASTM C 33; fine aggregate, natural, or manufactured sand.

2.4. GROUT

A. Description: ASTM C 1107, Grade B, non-shrink and non-metallic, dry hydraulic-cement grout with 5000 psi at 28 day compressive strength, suitable for indoor and outdoor applications.

2.5. FLOWABLE FILL

A. Description: ASTM C 150, Type I, low-strength portland-concrete, flowable-slurry mix with 100 to 200 psig at 28-day compressive strength.

2.6. WARNING TAPE

A. Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility; colored as follows:

B. Detectable Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored as follows:

1. Red: Electric.

2. Yellow: Gas, oil, steam, and dangerous materials.

3. Orange: Telephone and other communications.

4. Blue: Water systems.

5. Green: Sewer systems.

PART 3 - EXECUTION

3.1. PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.

1. Shore, support, and protect utilities encountered.

B. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Locate excavation support and protection systems clear of permanent construction so that construction and finishing of other work is not impeded.

D. 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 Owner not less than 14 days in advance of proposed utility interruptions.

2. Do not proceed with utility interruptions without Owner's written permission.

3.2. GENERAL EXCAVATION

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

2. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions:

a. 24-inches outside of concrete forms other than at footings.

b. 6-inches beneath bottom of concrete slabs on grade.

c. 6-inches beneath pipe in trenches, and the greater of 24-inches wider than pipe or 42-inches wide.

3. Blasting is prohibited.

3.3. EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit, unless otherwise indicated.

1. Clearance: Minimum 12-inches each side of pipe or conduit.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.

1. For pipes and conduit less than 6 inches in nominal diameter and flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.

2. For pipes and conduit 6-inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe circumference. Fill depressions with tamped sand backfill.

3. Excavate trenches 6-inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

D. Trench Bottoms: Excavate trenches 4-inches deeper than bottom of pipe elevation to allow for bedding course. Hand excavate for bell of pipe.

1. Excavate trenches 6-inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

3.4. BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Backfill trenches excavated under footings and within 18-inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings.

D. Provide 4-inch-thick, concrete-base slab support for piping or conduit less than 30 inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4-inches of concrete before backfilling or placing roadway sub-base.

E. Place and compact initial backfill of sub-base material, free of particles larger than 1-inch in any dimension, to a height of 12-inches over the utility pipe or conduit.

1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

F. Backfill voids with satisfactory soil while installing and removing shoring and bracing.

G. Place and compact final backfill of satisfactory soil to final subgrade elevation.

H. Install warning tape directly above utilities, 12-inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.5. BACKFILL COMPACTION

A. Place backfill and fill soil materials in layers not more than 6-inches in loose depth for material compacted by heavy compaction equipment, and not more than 4-inches in loose depth for material compacted by hand-operated tampers.

B. For utility trenches, compact each layer of initial and final backfill soil material at 85-percent.

3.6. PIPED UTILITY DEMOLITION

A. Disconnect, demolish, and remove piped utility systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.

2. Piping to Be Abandoned in Place: Drain piping. Fill abandoned piping with flowable fill, and cap or plug piping with same or compatible piping material.

3. Equipment to Be Removed: Disconnect and cap services and remove equipment.

4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make operational.

5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

B. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.7. GROUTING

A. Mix and install grout for equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.8. SOLDIER PILES AND LAGGING

A. Install steel soldier piles before starting excavation. Extend soldier piles below excavation grade level to depths adequate to prevent lateral movement. Space soldier piles at regular intervals not to exceed allowable flexural strength of wood lagging. Accurately align exposed faces of flanges to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment.

B. Install wood lagging within flanges of soldier piles as excavation proceeds. Trim excavation as required to install lagging. Fill voids behind lagging with soil, and compact.

C. Install wales horizontally at locations indicated on Drawings and secure to soldier piles.

3.9. SHEET PILING

A. Before starting excavation, install one-piece sheet piling lengths and tightly interlock vertical edges to form a continuous barrier.

B. Accurately place the piling, using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer. Limit vertical offset of adjacent sheet piling to 60 inches. Accurately align exposed faces of sheet piling to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment.

C. Cut tops of sheet piling to uniform elevation at top of excavation.

3.10. TIEBACKS

A. Drill, install, grout, and tension tiebacks. Test load-carrying capacity of each tieback and replace and retest deficient tiebacks.

1. Have test loading observed by a qualified professional engineer responsible for design of excavation support and protection system.

2. Maintain tiebacks in place until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.11. BRACING

A. Bracing: Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.

1. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by Architect.

2. Install internal bracing if required to prevent spreading or distortion of braced frames.

3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.12. FIELD QUALITY CONTROL

A. Survey-Work Benchmarks: Resurvey benchmarks regularly during installation of excavation support and protection systems, excavation progress, and for as long as excavation remains open. Maintain an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify Architect if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

B. Promptly correct detected bulges, breakage, or other evidence of movement to ensure that excavation support and protection system remains stable.

C. Promptly repair damages to adjacent facilities caused by installation or faulty performance of excavation support and protection systems.

3.13. 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 a sediment and erosion control plan, specific to the site that complies with EPA 832/R-92-005 or requirements of authorities having jurisdiction, whichever is more stringent.

B. Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established.

C. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.14. TREE PROTECTION

A. Erect and maintain temporary fencing around tree protection zones before starting site clearing. Remove fence when construction is complete.

1. Do not store construction materials, debris, or excavated material within fenced area.

2. Do not permit vehicles, equipment, or foot traffic within fenced area.

3. Maintain fenced area free of weeds and trash.

B. Do not excavate within tree protection zones, unless otherwise indicated.

C. Where excavation for new construction is required within tree protection zones, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.

1. Cover exposed roots with burlap and water regularly.

2. Temporarily support and protect roots from damage until they are permanently redirected and covered with soil.

3. Coat cut faces of roots more than 1-1/2 inches (38 mm) in diameter with an emulsified asphalt or other approved coating formulated for use on damaged plant tissues.

4. Backfill with soil as soon as possible.

D. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Architect.

1. Employ an arborist, licensed in jurisdiction where Project is located, to submit details of proposed repairs and to repair damage to trees and shrubs.

2. Replace trees that cannot be repaired and restored to full-growth status, as determined by Architect.

3.15. REMOVAL AND REPAIRS

A. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and earth and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils and rock or damaging structures, pavements, facilities, and utilities.

1. Remove excavation support and protection systems to a minimum depth of 48 inches below overlying construction and abandon remainder.

2. Fill voids immediately with compacted backfill.

3. Repair or replace, as approved by Engineer, adjacent work damaged or displaced by removing excavation support and protection systems.

B. Disposal: 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.

1. 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.

3.16. DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION 230300

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SECTION 230400 – HVAC COORDINATION DRAWINGS

PART 1 - GENERAL

1.1. SUMMARY

A. This section includes general requirements for coordination drawings.

1.2. SUBMITTALS

A. Product Submittals:

1. Coordination Drawings.

B. Close-Out Submittals:

1. Record Drawings: Revise Coordination Drawings to include the changes made in the field to accurately reflect the as-built conditions.

PART 2 - PRODUCTS (not used)

PART 3 - EXECUTION

3.1. COORDINATION DRAWING SUBMITTALS

A. Responsibilities: The Mechanical Contractor shall compile and complete the coordinated information provided in cooperation from the sub-contractors and vendors.

B. Coordination Drawings: Floor plans, including reflected ceiling, enlarged and partial site plans, sections and other details drawn to scale on which the following items are shown and coordinated with each other, using input from installers of the items involved.

1. Floor plan drawings shall be produced at 1/8, 1/4 and 1/2-inch equals 1-foot scale as needed to clearly represent the information. Mechanical and electrical rooms shall be produced at no less than 1/4-inch scale.

2. Site plan drawings shall be produced at 1-inch equals 10 or 20 feet as needed to clearly represent the information.

3. Dimensions, weights and mounting elevations shall be provided.

C. Coordinated Floor Plan Drawings: Floor plans with sufficient information to coordinate the building systems to avoid conflicts, including the following:

1. HVAC Systems:
    a. Duct Systems, including Insulation Thicknesses
    b. Louvers and Ventilators
    c. Piping Systems, including Insulation Thicknesses
    d. Equipment including Maintenance Clearances
    e. HVAC Control Systems
    f. Makeup Water Connections
    g. Water Treatment Equipment
2. Fire Protection Systems:
    a. Piping Systems
    b. Zone Control Valve Assemblies
    c. Backflow Prevention
    d. Equipment including Maintenance Clearances
3. Plumbing Systems:
    a. Piping Systems, including Insulation Thicknesses
    b. Backflow Prevention
    c. Equipment including Maintenance Clearances
    d. Energy and Flow Meters
    e. Vents Through Roof
4. Electrical
    a. Switchgear and Panelboards
    b. Equipment including Maintenance Clearances
    c. Conduit, 3-inches and larger or equivalent groups of smaller
5. Structural Members
6. Energy and Flow Meters
7. Variable Speed Drives, Motor Starters and Disconnects
8. Vibration Controls
9. Equipment Supports, Roof Curbs and Concrete Pads
10. Ceiling Heights
11. Cabinetry and Equipment

D. Coordinated Reflected Ceiling Plans: Ceiling layout with all components located and coordinates, including ceiling materials, ceiling access doors, light fixtures, sprinkler heads, diffusers and grilles, fire alarm devices, lighting control devices, HVAC control sensors, communications and audio-visual devices.

   1. Access to equipment and devices above ceiling shall be coordinated such that they are accessible from a ladder without moving other ceiling mounted devices. Proposed access door locations must be approved by the Owner/Engineer.

E. Coordinated Site Plans: Partial site plans with site work including service piping, conduits, manholes and equipment.

END OF SECTION 230400

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SECTION 230500 – HVAC FIRESTOPPING

PART 1 - GENERAL

1.1. SUMMARY

A. This section includes firestopping requirements and information for Division 23 and 25 work.

1.2. DEFINITIONS

A. Firestopping: The use of a material or combination of materials in a fire and/or smoke-rated structure (wall or floor) where it has been breached, so as to restore the integrity of the fire and/or smoke rating on that wall or floor.

B. System: The use of a specific firestop material or combination of materials in conjunction with a specific wall or floor construction type and a specific penetrant(s).

C. Barrier: Any bearing or non-bearing wall or floor that has an hourly fire and smoke rating.

D. Through-Penetration: Any penetration of a fire-rated wall or floor that completely breaches the barrier.

E. Membrane-Penetration: Any penetration in a fire and/or smoke-rated wall or floor/roof-ceiling assembly that breaches only one side of the barrier.

F. Approved Testing Agencies: Not limited to: Underwriters Laboratory (UL), Factory Mutual (FM), and Intertek Group (IG).

1.3. PERFORMANCE REQUIREMENTS

A. Penetrations: Provide through-penetration and membrane-penetration firestop systems that are produced and installed to resist the spread of fire, passage of smoke and other hot gases according to requirements indicated, to restore the original fire and smoke resistance rating of assembly penetrated.

B. Provide and install complete penetration firestopping systems that have been tested and approved by nationally accepted testing agencies per ASTM E814 or UL 1479 fire tests in a configuration that is representative of field conditions.

1. F-Rated Systems: Provide firestop systems with F-ratings indicated and as required by the Building Code.

2. T-Rated Systems: Provide firestop systems with T-ratings and F-ratings indicated and as required by the Building Code.

3. L- Rated Systems: Provide firestop systems with L- ratings less than 5cfm/sf.

4. W-Rated systems: Provide firestop systems that are resistant to water. For piping penetrations, provide moisture-resistant through-penetration firestop systems.

C. For penetrations involving non-metallic, CPVC, PVC, or plastic piping, tubing or conduit, provide firestop systems that are chemically compatible in accordance with Manufacturer requirements.

D. For penetrations involving insulated piping, provide firestop systems not requiring removal of insulation.

E. For penetrations involving fire or fire/smoke dampers, only firestop products approved by the damper manufacturer shall be installed in accordance with the damper installation instructions.

F. Firestopping products shall have flame spread ratings less than 25 and smoke-developed ratings less than 450, as determined per ASTM E 84, except firestop products installed in plenum spaces shall have a smoke developed rating less than 50.

G. Engineering Judgment (EJ): Where there is no specific third party tested and classified firestop system available for an installed condition, the Contractor shall obtain from the firestopping material manufacturer an Engineering Judgment (EJ) to be submitted to the Authority Having Jurisdiction (AHJ) and Engineer for approval. The EJ shall follow International Firestop Council (IFC) guidelines.

1.4. SUBMITTALS

A. Product Submittals:

1. Product Data: For each type of firestopping product selected. Manufacturers certification must verify that firestopping materials are free of asbestos, lead and contain volatile organic compounds (VOCs) within limits of the local jurisdiction. Include the following information:

a. Design Listings: Submit system design listings, including illustrations, from a qualified testing and inspecting agency that is applicable to each firestop configuration.

b. Installation Instructions: Submit the manufacturer's installation instruction for each firestop assembly.

c. Engineering Judgements: Where there is no specific third party tested and classified firestop system available for a particular configuration, the Contractor shall obtain from the firestopping material manufacturer an Engineering Judgment (EJ) for submittal.

d. Firestop Schedule: Submit schedule itemizing the following:

1) Manufacturer's product reference numbers and/or drawing numbers.

2) Listing agency's design number.

3) Penetrating Item Description/Limits: Material, size, insulated or uninsulated, and combustibility.

4) Maximum allowable annular space or maximum size opening.

5) Construction type.

6) F rating and, if applicable, T, L, and W ratings.

1.5. QUALITY ASSURANCE

A. Provide firestopping system design listings from FM Global's "Building Materials Approval Guide", Intertek's "Directory of Listed Building Products", or UL's "Fire Resistance Directory" in accordance with the appropriate ASTM Standard(s).

B. Single Source Limitations: Obtain firestop systems for all conditions from a single manufacturer.

1. Materials from different firestop manufacturers shall not be installed in the same firestop system or opening.

C. Firestopping material shall be asbestos and lead free and shall not incorporate nor require the use of hazardous solvents.

D. Firestopping sealants must be flexible, allowing for normal movement.

E. Firestopping materials shall not shrink upon drying as evidenced by cracking or pulling back from contact surfaces such that a void is created.

F. Firestopping materials shall be moisture resistant and may not dissolve in water after curing.

G. Materials used shall be in accordance with the manufacturer's written installation instructions.

H. All firestop materials shall be installed prior to expiration date. Store and handle materials per manufacturer's instructions to prevent deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

1.6. COORDINATION

A. Coordinate areas prior to firestopping installation with the Owner, Construction Manager and/or all other Contractors.

B. Coordinate construction of openings and penetrating items to ensure that firestopping assemblies are installed according to specified requirements. Opening shall not exceed maximum restrictions allowable for annular spacing per listing or acceptable Engineering Judgments.

C. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.

D. Do not conceal firestopping installations until the Owner's inspection agency or Authorities Having Jurisdiction have examined each installation.

E. Schedule firestopping after installation of penetrants and joints but prior to concealing or obstructing access to areas requiring firestopping.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Emerson / Nelson Firestop Products
2. Hilti
3. 3M, Fire Protection Products Division
4. Tremco

2.2. FIRESTOPPING

A. Firestopping products specified in system design listings by approved testing agencies may be used providing they conform to the construction type, penetrant type, annular space requirements and fire rating involved in each separate assembly.

B. Accessories: Provide components for each firestop system that is needed to install fill materials and to comply with "Performance Requirements" Article. Use only components specified by the firestopping manufacturer and by the approved testing agencies for the firestop systems indicated. Accessories include, but are not limited to the following items:

1. Permanent forming/damming/backing materials, including the following:

a. Slag wool fiber insulation.

b. Foams or sealants used to prevent leakage of fill materials in liquid state.

c. Fire-rated form board.

d. Polyethylene/polyurethane backer rod.

e. Rigid polystyrene board.

2. Temporary forming materials.

3. Substrate primers.

4. Steel sleeves

C. All firestopping products and systems shall be designed and installed so that the basic sealing system will allow the full restoration of the thermal and fire resistance properties of the barrier being penetrated with minimal repair if penetrants are subsequently removed.

D. Mold Resistance: Provide penetration firestopping with mold and mildew resistance rating of zero (0) as determined by ASTM G21.

PART 3 - EXECUTION

3.1. GENERAL REQUIREMENTS

A. Provide firestop systems consisting of a material, or combination of materials installed to retain the integrity of fire resistance rated construction by maintaining an effective barrier against the spread of flame, smoke and/or hot gases through penetrations, fire resistive joints, and perimeter openings in accordance with the requirements of the Building Code for this project.

B. Firestop systems shall be used in locations including, but not limited to, the following:

1. Penetrations through fire resistance rated floor and roof assemblies including both empty openings and openings containing penetrants.

2. Penetrations through fire resistance rated wall assemblies including both empty openings and openings containing penetrants.

3. Membrane penetrations in fire resistance rated wall assemblies where items penetrate one side of the barrier.

3.2. EXAMINATION

A. Examine substrates and conditions for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance.

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

C. Verify that all pipes, conduits, cables, and/or other items which penetrate fire-rated construction have been permanently installed prior to installation of firestops.

3.3. PREPARATION

A. Surface Cleaning: Clean out openings immediately before installing firestop systems to comply with written recommendations of firestopping manufacturer and the following requirements:

B. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of firestop systems.

C. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with firestop systems. Remove loose particles remaining from cleaning operation.

D. For those products requiring mixing before application, comply with firestopping manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

3.4. INSTALLATION

A. General: Install firestop systems to comply with firestopping manufacturer's written installation instructions and published drawings for products and applications indicated.

B. Apply firestopping in accordance with approved testing agencies listed system designs or manufacturer's EJ per the manufacturer's installation instructions.

C. Verify that environmental conditions are safe and suitable for installation of firestop products. Application areas shall be protected from weather, dry and within recommended temperature and humidity ranges of materials being installed.

D. Install forming/damming/backing materials and other accessories required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire resistance ratings required.

E. Install metal framing, mechanical attachments, safing materials and firestop materials as applicable within the system design.

F. Install fill materials for firestop systems by proven techniques to produce the following results:

1. Fill voids, joints and cavities formed by openings, forming materials, accessories, and penetrating items as required to achieve fire-resistance ratings indicated.

2. Apply materials so they fully contact and adhere to substrates formed by openings and penetrating items.

3. For fill materials that will remain exposed after completing work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

4. Tool non-sag firestop materials after their application and prior to the time skinning begins. Use tooling agents approved by the firestopping manufacturer.

G. On vertical pipe penetrations, lift riser clamps to permit the installation of firestopping around the entire pipe penetration. For penetrations involving fire or fire/smoke dampers, only firestop products approved by the damper manufacturer shall be installed in accordance with the damper installation instructions.

3.5. FIELD QUALITY CONTROL

A. Inspecting Agency: Authorities Having Jurisdiction, the Owner, or Owner's Representative shall be allowed to perform random destructive testing during inspection of firestop systems to verify compliance per listings or manufacturer's installation instructions. All areas of work must be accessible until inspection by the applicable Authorities Having Jurisdiction and inspection agencies. The contractor shall be responsible to repair all tested assemblies with no cost to the owner.

1. Refer to Division 1 and Section 230100 regarding Special Inspections requirements.

B. Proceed with enclosing firestop systems with other construction only after inspections are complete.

C. Where deficiencies are found as determined by the Engineer, remove and replace firestop systems so they comply with requirements.

3.6. CLEANING AND PROTECTION

A. Clean off excess fill materials adjacent to openings, as work progresses by methods and with cleaning materials that are approved in writing by firestopping manufacturer(s) and that do not damage materials in which openings occur. Leave finished work in neat, clean condition with no evidence of spillovers or damage to adjacent surfaces.

B. Provide final protection and maintain conditions during and after installation that ensure firestop systems are without damage or deterioration at time of Owner Acceptance. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated firestop systems immediately and install new materials to produce firestop systems complying with specified requirements.

END OF SECTION 230500

SECTION 230511 – HVAC ELECTRICAL PROVISIONS

PART 1 - GENERAL

1.1. SUMMARY

A. This section includes electrical equipment, materials and work that are the responsibility of Division 23.

1.2. SUBMITTALS

A. Product Submittals:

1. Product Data: For each type of device, include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

2. Electrical Connections: Submitted equipment nameplates shall be coordinated with the indicated design electrical characteristics. If the submitted equipment requires changes to the electrical connection(s) (including conduit, wire, circuit breaker, fuse, starter, and disconnect sizes, connection locations, etc.) comply with the requirements of Section 230100. Any changes required to accommodate the equipment shall be responsibility of the contractor.

a. Proposed changes to the design shall be submitted to the Engineer for review and approval.

b. Accepted changes shall be noted by the contractor on the as-built documentation.

B. Close-Out Submittals:

1. Operation and Maintenance Data: For disconnects, motor starters and combination motor starters and disconnects, to include in emergency, operation and maintenance manuals.

1.3. QUALITY ASSURANCE

A. Source Limitations: Obtain motor starters, disconnect switches and combination motor starters and disconnect switches of a single type through one source from a single manufacturer.

1. Exceptions: Disconnect switches that are factory-mounted to HVAC equipment may be provided by the equipment manufacturer.

B. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

1. Where requirements of Division 23, Division 26 or NFPA 70 conflict, conform to the strictest requirements.

C. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

D. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

1.4. EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: One set for each fused device.

PART 2 - PRODUCTS

2.1. EQUIPMENT ENCLOSURES

A. Provide NEMA-rated equipment enclosures for all disconnect switches, motor starters, control panels, variable speed controllers and other similar electrical equipment. When not otherwise indicated, provide enclosures based on the environments of the installations.

1. Inside, Clean Spaces without Water Piping: NEMA 1.

2. Inside, Utility Spaces and Spaces with Water Piping: NEMA 12.

3. Outside, Normal Ambient Conditions: NEMA 3R.

4. Inside or Outside, Water Features and Equipment (Pools, Fountains, Aquariums, etc.) Spaces: NEMA 4X

5. Inside or Outside, Manholes, Tunnels and Sumps: NEMA 6

6. Inside or Outside, NEC Hazard Class 1 Locations: NEMA 8

7. Inside or Outside, NEC Hazard Class 2 Locations: NEMA 9

2.2. DISCONNECT SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Eaton

2. ABB/General Electric

3. Schneider Electric/Square D

4. Siemens

B. Fusible Disconnect Switches: Single-throw, heavy-duty, service-rated fusible switch, rated for 200 to 600Vac and labeled and listed UL 98 and NEMA KS 1, Type HD with silver-tungsten type fuse clips and equipment ground and neutral kit. When a neutral is not necessary, bond the neutral bus to the enclosure for use as grounding bus. Internal current-carrying components shall be solid copper. Provide auxiliary contacts when needed for control system interface.

C. Non-Fusible Disconnect Switches: Single-throw, heavy-duty, service-rated switch, rated for 200 to 600Vac and labeled and listed UL 98 and NEMA KS 1, Type HD with equipment ground and neutral kit. When a neutral is not necessary, bond the neutral bus to the enclosure for use as grounding bus. Internal current-carrying components shall be solid copper. Provide auxiliary contacts when needed for control system interface.

D. Provide switch accessories required to meet the system requirements indicated.

2.3. MOTOR STARTERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Eaton

2. ABB/General Electric

3. Schneider Electric/Square D

4. Siemens

B. Description: Full-voltage, electrically-held, non-reversing, magnetic motor controllers with 24Vac control circuit, hand-off-auto (HOA) switch, push-to-start switch, manual reset switch, auxiliary control and monitoring contacts and accessories required to meet the system requirements indicated. Cover door shall have red and green pilot lights. The green light shall illuminate when “on”, and red shall illuminated when “off”.

2.4. COMBINATION MOTOR STARTERS AND DISCONNECT SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Eaton

2. ABB/General Electric

3. Schneider Electric/Square D

4. Siemens

B. Description: Combination magnetic motor starter and circuit breaker disconnecting means with auxiliary contacts.

1. Disconnecting Means: Thermal magnetic type molded-case circuit breaker (MCCB) with adjustable instantaneous-trip for each pole, auxiliary control and monitoring contacts and test trip button.

2. Motor Starter: Full-voltage, electrically-held, non-reversing, magnetic motor controllers with 24Vac control circuit, hand-off-auto (HOA) switch, push-to-start switch, manual reset switch, auxiliary control and monitoring contacts and accessories required to meet the system

requirements indicated. Cover door shall have red and green pilot lights. The green light shall illuminated when “on”, and red shall illuminated when “off”.

2.5. MANUAL MOTOR SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Eaton
2. ABB/General Electric
3. Schneider Electric/Square D
4. Siemens

B. Description: Manual motor starter and disconnect switch with thermal overload protection for fractional horsepower motors. Toggle switch shall provide manual “on/off” control of one or two-pole single-phase motors rated up to 1 horsepower. The enclosure shall have green pilot light. The green light shall illuminate when “on”. The switch shall have a hand guard to prevent accidental operation and provisions for a padlock in the “off” position. The switch shall be rated for single or two-speed applications as indicated. The enclosure shall be for flush wall-mounting where possible and surface wall-mounting where not.

2.6. FUSES

A. Description: Non-renewable cartridge fuses of the type and size required by NFPA 70 and Division 26.

2.7. SHORT-CIRCUIT CURRENT RATINGS

A. Overcurrent protection devices shall be rated for the ampere interruption current rating indicated in the Division 26 documents. Where the rating is not indicated, provide devices rated for 65,000 AIC.

2.8. POWER AND CONTROL CABLING AND RACEWAY

A. Low-Voltage (100 to 600 V) Power Feeders: Size conductors and raceway per NFPA 70 and Division 26 based on equipment nameplate requirements and manufacturer’s installation recommendations.

B. Control-Voltage (Up to 24 V) Cabling: Provide control cabling for HVAC system per NFPA 70 and Division 26 based on the system manufacturer’s installation recommendations.

1. Paired Cabling: No. 16 AWG Type CMP plenum-rated twisted pair.
2. Class 1 and 2 Control Circuits: Stranded copper Type THHN-THWN.
3. Class 3 Control Circuits: Stranded copper Type TW or TF.

C. Power Conductors: Copper, solid for No. 10 AWG and smaller and stranded for No. 8 AWG and larger, with THHN-THWN insulation. Aluminum conductors will not be accepted.

D. Grounding Conductors: Copper, solid for No. 8 AWG and smaller and stranded for No. 6 AWG and larger, with THHN-THWN insulation. Aluminum conductors will not be accepted.

E. Conduit:

1. EMT (electrical metallic tubing): Indoor, above-grade applications not subject to damage.

2. RGS (rigid galvanized steel): Indoor, above-grade applications subject to damage and outdoor, above-grade applications.

3. RNC (rigid non-metallic conduit), Type Schedule 40 PVC: Indoor and outdoor, below-grade applications.

4. FMC (flexible metallic conduit): Indoor, above-ceiling applications.

5. LFMC (liquid-tight flexible metal conduit): Outdoor, above-grade applications.

PART 3 - EXECUTION

3.1. INSTALLATION

A. Disconnect Switches: Provide disconnect switches for all HVAC equipment. Disconnect switches shall be sized to comply with NFPA 70. Single fan, blower and pump motors shall be based on nameplate horsepower. All other applications shall be based on nameplate total kW rating. Disconnects shall be provided with dual-element fuses sized based on equipment nameplate rating.

1. Service Disconnect Switches: Where the disconnecting means is not within the line-of-sight, as defined by NFPA 70 and the authority having jurisdiction (AHJ), an additional service disconnect shall be located adjacent to the equipment it feeds.

DISCONNECT SWITCH SIZES for MOTORS						
AMPERAGE RATING	MAX HP at VOLTAGE/PHASE					
	115V/1ph	200V/1ph	230V/1ph	200V/3ph	230V/3ph	460V/3ph
30A	1.5	3	3	5	7.5	15
60A	3	7.5	10	15	15	30
100A	-	-	-	25	25	60
200A	-	-	-	50	60	100
400A	-	-	-	100	125	250

DISCONNECT SWITCH SIZES for EQUIPMENT							
AMPERAGE RATING	MAX KW at VOLTAGE/PHASE						
	120V/1ph	208V/1ph	240V/1ph	277V/1ph	208V/3ph	240V/3ph	480V/3ph
30A	2.8	5.0	5.8	6.6	8.6	10.0	19.9
60A	5.8	10.0	11.5	13.3	17.3	19.9	39.9

100A	9.6	16.6	19.2	22.2	28.8	33.2	66.4
200A	19.2	33.3	38.4	44.3	57.6	66.4	132.9
400A	38.4	66.6	76.8	88.6	115.1	132.9	265.7
600A	57.6	99.8	115.2	133.0	172.7	199.3	398.6

B. Motor Starters: Provide all motor starters where required for HVAC equipment to operate as intended. Motor starters shall be sized to comply with NFPA 70 and NEMA rated for magnetic starters.

NEMA STARTER SIZES					
NEMA SIZE	MAX HP at MOTOR VOLTAGE/PHASE				
	115V/1ph	230V/1ph	200V/3ph	230V/3ph	460V/3ph
00	0.33	1	1.5	1.5	2
0	1	2	3	3	5
1	2	3	7.5	7.5	10
2	-	7.5	10	15	25
3	-	-	25	30	50
4	-	-	40	50	100
5	-	-	75	100	200

C. Combination Motor Starters and Disconnect Switches: Provide combination motor starters and disconnect switches that meet the requirements of the "Motor Starters" article above. Combination motor starters and disconnect switches shall be used unless otherwise noted or prohibited by NFPA 70.

D. Manual Motor Switches: Provide manual motor switches for fractional horsepower fan, blower and pump motors that do not require automated start and stop functions.

E. Furnish and install devise fuses per equipment unit nameplate.

F. Size and adjust circuit breaker disconnect switches per equipment unit nameplate.

G. Electrical Connections: All electrical connections shall be made in accordance with equipment manufacturer's recommendations and in accordance with NFPA 70. Install and ground equipment connections in accordance with the requirements of NFPA 70 and Division 26.

1. Electrical Connections, Low Voltage (100 to 600 V): Division 23 contractor is responsible for power wiring and conduit from the equipment connections to the disconnecting means. Division 26 is responsible for the power circuit from the power source to the disconnecting means.

2. Electrical Connections, Control Voltage (Up to 24 V): Division 23 contractor is responsible for all control voltage wiring and conduit for HVAC equipment and controls from the low voltage power source disconnecting means. Division 26 is responsible for the low voltage power circuit from the power source to the disconnecting means.

    a. Low Voltage Disconnecting Means: Where dedicated low voltage circuits are indicated in Division 26 documents, the disconnecting means shall be defined as the disconnect switch or junction box provided. Where dedicated low voltage circuits are not explicitly indicated in Division 26 documents, the disconnecting means shall be defined as 20A/1P spare circuit breakers in panelboards.

H. Wiring Pathway, Low and Control Voltage: All low and control voltage power and control wiring shall be installed in conduit unless otherwise noted.

1. Surface-mounted raceway may only be used when indicated or Engineer approved prior to installation. In most cases, conduits shall be installed within walls, above ceilings and below floor slabs. Cut and repair substrates to install raceway.

2. Control voltage cabling shall be plenum-rated and organized with J-hooks when control cabling is not required by the Engineer to be installed in conduit.

I. Conduit:

1. Flexible Connections: Provide flexible connections for all vibrating equipment including fans, pumps, compressors, etc. Flexible connections shall be no more than 24-inches long.

2. Areas Subject to Damage: In areas where the conduit will be exposed and is subject to damage, such as mechanical equipment rooms, RGS conduit shall be installed to no less than 8-feet above finished floor and EMT may be used above 8-feet.

J. Grounding and Bonding: Ground and bond equipment and circuits in accordance with the requirements of NFPA 70 and Division 26.

K. Install duct-mounted smoke detectors, furnished and wired by Division 26. Provide duct access doors for proper maintenance and access.

L. Smoke-rated life-safety dampers shall be wired and controlled by Division 26.

M. Smoke control system devices shall be wired and controlled by Division 26.

3.2. FIELD QUALITY CONTROL

A. Comply with NFPA 70E per OSHA 29CFR Part 1910.5, Appendix A.

3.3. DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain electrical devices.

END OF SECTION 230511

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SECTION 230513 – HVAC EQUIPMENT MOTORS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes general requirements for all HVAC motors

1.2. QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

B. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

C. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

PART 2 - PRODUCTS

2.1. GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

C. Motors for fans and pumps shall be selected for the maximum brake-horsepower listed in the equipment schedules and no more than 85% of the nominal rated horsepower excluding the service factor.

2.2. MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea-level.

B. 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.

2.3. POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motors.

1. General Use: Open drip-proof (ODP) motors.

B. Efficiency: All motors shall be Premium Efficiency conforming to the requirements of NEMA MG1 Part 31. Conform to 10 CFR Part 431 published by the US Department of Energy - Efficiency standard for integral horsepower motors.

1. Minimum efficiency shall meet the requirements of the State Energy Conservation Code and ASHRAE 90.1.

C. Service Factor: 1.15.

1. Multispeed Motors: Variable torque.

2. For motors with 2:1 speed ratio, consequent pole, single winding.

3. For motors with other than 2:1 speed ratio, separate winding for each speed.

D. Rotor: Random-wound, squirrel cage.

E. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

F. Temperature Rise: Class B.

G. Insulation: Class F.

H. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.

2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

I. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4. POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.

2. Inverter-Duty Motors: Motors shall be “Inverter-Duty” rated according to NEMA MG 1 Part 31, “Requirements for Definite Purpose Inverter-Fed Polyphase Motors”, with minimum Class F temperature rise and Class H insulation. NEMA duty rating code on motor nameplate shall indicate “Inverter-Duty”. Other duty rating code markings such as “Inverter-Ready” are not acceptable.

3. Shaft Grounding Rings (SGR): Motors 5 hp and larger shall have solid or split type shaft grounding rings designed to prevent bearing damage due to adjustable speed drive induced currents. SGR shaft diameter shall match the motor’s standard NEMA “u” dimension.

4. Shaft Grounding Rings (SGR): Multi-phase motors shall have solid or split type shaft grounding rings designed to prevent bearing damage due to adjustable speed drive induced currents. SGR shaft diameter shall match the motor’s standard NEMA “u” dimension.

5. Over-Speeding: Variable frequency drives shall not be set above 60 Hz.

a. Exceptions:

1) Air Handling Units with Setback Schedules: Variable frequency drives shall not operate over 80 Hz and motors shall not operate over 2,400 RPM for direct-drive fans used in air handling units.

6. Under-Speed Operation: Motors shall be capable of continuous operation at minimum design operating speed indicated on the drawings. Where minimums are not indicated, motors shall be capable of continuous operation at the following minimum speeds.

    a. Fans: 18 Hz (30-percent).

    b. Pumps: 12 Hz (20-percent).

C. Electronically-Communicated (EC) Motors

1. Electronically-communicated (EC) motors, also known as brushless DC electric (BLDC) motors, shall be NEMA MG 1, totally enclosed fan cooled (TEFC), inverter-use, motors with integrated microprocessor speed controller designed for variable speed and torque fan and pump applications.

    a. Speed controller shall be programmed with safeties to avoid damaging conditions and unstable fan / pump operation. Firefighter's safety override mode shall allow bypass of most speed controller safeties.

    b. Speed controller shall comply with requirements of Section 230514.

2.5. SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.

2. Split phase.

3. Capacitor start, inductor run.

4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

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SECTION 230514 – VARIABLE SPEED CONTROLLERS

PART 1 - GENERAL

1.1. SUMMARY

A. This section includes solid-state, pulse-width modulated, variable speed motor controllers for three-phase, squirrel-cage induction motors.

1.2. SUBMITTALS

A. Product Submittals:

1. Product Data: For each type of variable speed controller, include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

B. Close-Out Submittals:

1. Operation and Maintenance Data: For variable speed controllers, all installed devices, and components to include in emergency, operation, and maintenance manuals.

a. Routine maintenance requirements for variable speed controllers and all installed components.

b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

2. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

3. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.3. QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Source Limitations: Obtain variable speed controllers of a single type through one source from a single manufacturer.

1. Exceptions: Variable speed controllers that are factory-mounted to HVAC equipment, such as chillers and cooling towers, and branded by the equipment manufacturer may be provided by the equipment manufacturer.

C. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

D. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

E. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for variable speed controllers minimum clearances between the controllers and adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

1.4. DELIVERY, STORAGE, AND HANDLING

A. Deliver variable speed controllers in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

B. Store variable speed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.5. PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without de-rating, under the following conditions, unless otherwise indicated:

1. Ambient Temperature: 32 to 105 deg F.

2. Humidity: Less than 90 percent (non-condensing).

3. Altitude: Not exceeding 3300 feet.

B. NEMA-rated enclosures for the installed environment. Refer to Section 230511.

1.6. COORDINATION

A. Coordinate layout and installation of variable speed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

C. Coordinate features of variable speed controllers, installed units, and accessory devices with pilot devices and control circuits to which they connect.

D. Coordinate features, accessories, and functions of each variable speed controller and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.7. WARRANTY

A. Special Warranty: Manufacturer’s complete parts and labor warranty for 3-years from the date of Owner Acceptance.

1.8. EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Spare Fuses: One set of three for each variable speed controller.

2. Indicating Lights: Two of each type installed.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB.
2. Danfoss.
3. Yaskawa.

2.2. VARIABLE FREQUENCY CONTROLLERS

A. Description: NEMA 2, integrated-gate bipolar transistor (IGBT), pulse-width modulated (PWM), variable frequency controller listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency. Provide unit suitable for premium motor efficiency operation as defined by NEMA MG 1.

1. Provide 6, 12 or 18-pulse drives as needed to meet the harmonic distortion limits.

B. Design and Rating: Match load type such as fans, blowers and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

C. Output Rating: 3-phase; 6 to 66 Hz, with torque constant as speed changes.

D. Unit Operating Requirements:

1. Input ac voltage tolerance of 208 V, plus or minus 5 percent; 380 to 500 V, plus or minus 10 percent; and 525 to 575 V, plus or minus 10 percent.

2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.

3. Minimum Efficiency: 96 percent at 60 Hz, full load.

4. Minimum Displacement Primary-Side Power Factor: 96 percent.

5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.

6. Starting Torque: 100 percent of rated torque or as indicated.

7. Speed Regulation: Plus or minus 1 percent.

E. Isolated control interface to allow controller to follow control signal over an 11:1 speed range with an electrical signal of 4 to 20 mA at 24V.

F. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.

2. Maximum Speed: 80 to 100 percent of maximum rpm.

3. Acceleration: 2 to a minimum of 22 seconds.

4. Deceleration: 2 to a minimum of 22 seconds.

5. Current Limit: 50 to a minimum of 110 percent of maximum rating.

6. Self-Protection and Reliability Features:

7. Input transient protection by means of surge suppressors.

8. Under and over-voltage trips; inverter over-temperature, overload, and overcurrent trips.

9. Motor Overload Relay: Adjustable and capable of NEMA 2, Class 20 performance.

10. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.

11. Instantaneous line-to-line and line-to-ground overcurrent trips.

12. Loss-of-phase protection.

13. Reverse-phase protection.

14. Short-circuit protection.

15. Motor over-temperature fault.

G. Multiple-Motor Capability: Controller suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.

H. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional auto-speed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

I. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.

J. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

K. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

L. Input Line Conditioning: 5% Line Reactor.

M. VFC Output Filtering: Load reactors (dV/dt filters) for distances greater than 50 feet between drive and load.

N. Status Lights: Door-mounted LED indicators shall indicate the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

O. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.

P. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (Vdc).
9. Set-point frequency (Hz).
10. Motor output voltage (V).

Q. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the building automation system (BAS) or other control systems:

a. 0 to 10-V dc.

b. 0-20 or 4-20 mA.

c. Potentiometer using up/down digital inputs.

d. Fixed frequencies using digital inputs.

e. RS485.

f. Keypad display for local hand operation.

3. Output Signal Interface: Minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:

a. Output frequency (Hz).

b. Output current (load).

c. DC-link voltage (VDC).

d. Motor torque (percent).

e. Motor speed (rpm).

f. Set-point frequency (Hz).

4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

a. Motor running.

b. Set-point speed reached.

c. Fault and warning indication (over-temperature or overcurrent).

d. PID high- or low-speed limits reached.

R. Communications: Provide an RS485 interface allowing variable frequency controller to be used with an external system within a multi-drop local area network (LAN) configuration. Interface shall allow all parameter settings of variable frequency controllers to be programmed via building automation system (BAS) control. Provide capability for variable frequency controllers to retain these settings within the nonvolatile memory.

1. BAS Interface: Factory-installed hardware and software to enable the building automation system (BAS) to monitor, control and display unit status and alarms. BACnet communication interface with the BAS shall enable the BAS operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel shall be available through the BAS.

S. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller-off-bypass selector switch sets mode, and indicator lights give indication of mode selected. Unit shall be capable of stable operation (starting, stopping, and running), with motor completely disconnected from controller (no load).

T. Integral Disconnecting Means: Door interlocked, NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 65,000A.

U. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

2.3. ENCLOSURES

A. Provide NEMA-rated enclosure appropriate for the installed environment. Refer to Section 230511 for more information.

2.4. ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

D. Control Relays: Auxiliary and adjustable time-delay relays.

E. Standard Displays: Door mounted display shall include:

1. Output frequency (Hz).
2. Set-point frequency (Hz).
3. Motor current (amperes).
4. DC-link voltage (VDC).
5. Motor torque (percent).
6. Motor speed (rpm).
7. Motor output voltage (V).

F. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

PART 3 - EXECUTION

3.1. EXAMINATION

A. Examine areas, surfaces, and substrates to receive variable speed controllers for compliance with requirements, installation tolerances and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before variable speed controllers installation.

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

3.2. APPLICATIONS

A. Select features of each variable speed controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load.

B. Select horsepower rating of controllers to suit motor controlled.

C. Select amperage rating of controllers to suit multiple motor applications.

D. Variable speed drives shall be furnished for each motor. Do not operate more than one motor on a single variable speed drive unless otherwise noted.

3.3. INSTALLATION

A. Anchor each variable speed controller assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with mounting surface.

B. Comply with mounting and anchoring requirements specified in Division 26.

C. Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26.

D. Seal interior electronics in plastic wrap to protect from dirt during installation. Remove plastic wrap when complete. Cover enclosure vents with MERV-5 filter media prior to using VFD’s during construction. Keep VFD’s clean. Vacuum dirt and metal shavings from inside and outside of VFD enclosure.

3.4. IDENTIFICATION

A. Identify variable speed controllers, components, and control wiring according to Section 230553.

3.5. CONTROL WIRING INSTALLATION

A. Install wiring between variable speed controllers and remote devices according to Division 26.

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic-control devices where applicable.

1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.

2. Connect selector switches with control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.6. CONNECTIONS

A. Conduit installation requirements are specified in Division 26. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment according to Division 26.

C. VFD Cable:

1. Provide Type TC-ER: Comply with NEMA WC 70/ICEA S-95-658 and UL 1277. Cable designed for use with VFCs, with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire, and sunlight- and oil-resistant outer PVC jacket. Extra-flexible stranded for all sizes. Armoring is required for cable not installed in conduit.

3.7. FIELD QUALITY CONTROL

A. Factory-trained technician shall perform start-up.

1. Technician shall utilize manufacturer’s software with laptop to upload parameters in compliance with manufacturer’s warranty.

2. Start-ups shall be witnessed by the Owner and performed prior to TAB.

B. Perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.8. ADJUSTING

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

3.9. DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain variable frequency controllers.

END OF SECTION 230514

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SECTION 230516 – EXPANSION FITTINGS AND LOOPS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes expansion joints, expansion loops, fittings, supports, guides and anchors.

1.2. ACTION SUBMITTALS

A. Delegated-Design Submittals:

1. For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.

a. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.

b. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.

c. Alignment Guide Details: Detail field assembly and attachment to building structure.

d. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

B. Product Submittals:

1. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1. PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable and rated for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.2. FLEXIBLE HOSE TYPE EXPANSION COMPENSATORS

A. Flexible-Hose Expansion Loop: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose. Flexible hoses constructed of corrugated metal inner hoses and braided outer sheaths.

1. Copper Piping Systems: Copper alloy fittings with solder joint end connections for 2 inches NPS and smaller and threaded for 2-1/2 inches NPS and larger. Stainless steel hoses and single-braid stainless steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.

2. Steel Piping Systems: Carbon steel fittings with threaded end connections for 2 inches NPS and smaller and flanged for 2-1/2 inches NPS and larger. Stainless steel hoses and single-braid stainless steel sheaths for 2 inches NPS and smaller and double-braid for 2-1/2 inches NPS and larger with 275 psig at 70 deg F and 200 psig at 600 deg F ratings.

2.3. ALIGNMENT GUIDES, SUPPORTS AND ANCHORS

A. Pipe Supports: Factory-fabricated steel sliding supports with 1/2-inch thick low-friction graphite on both upper and lower backing. Graphite plates shall be epoxy bonded and riveted to steel components. All pipe saddles shall be 3/8” minimum thickness. Advanced Thermal Systems or Engineer approved equal.

B. Alignment Guides: Factory-fabricated steel alignment guides with 1/2-inch thick low-friction graphite on both upper and lower backing plates and two-section guiding slider. Graphite plates shall be epoxy bonded and riveted to steel components. All pipe saddles shall be 3/8” minimum thickness. Advanced Thermal Systems or Engineer approved equal.

C. Anchors: Steel, factory-fabricated anchor. Zinc-coated mechanical fasteners shall be insert-wedge-type stud with expansion plug anchor for use in hardened Portland cement concrete, with tension and shear capacities appropriate for application.

D. All pipe supports, guides, anchors, and associated structural steel shall be provided with:

1. Shop-applied oxide primer meeting the following requirements:

a. One coat primer at 2.5-3.5 mils DFT (dry finish thickness)

b. Meet ASTM 4541 for adhesion with not less than 1150 psi

c. Meet ASTM 4585 for humidity with no more than 1% rust after 5,000 hours exposure.

d. Meet ASTM-D 2794 for impact with no visible cracking or delamination after 160 inch-pounds direct impact.

e. Meet ASTM B117 for salt spray with no more than 3% rust or plane, no more than 1/64 of an inch creep at scribe after 10,250 hours.

f. Clean per SSPC-SP3 power tool cleaning and meet slip co-efficient of 0.056.

2. Two-part polyamidoamine epoxy top coat meeting the following requirements:

a. Color: Red

b. 2 coats, 4-6 mils per coat for a total of 8-12 mils required for the top coat.

c. Meet ASTM 4541 Type II for adhesion with not less than 1600 psi pull, average of 3 tests.

d. Meet ASTM 4585 for humidity with no blistering, cracking, checking, rusting or delamination of film after 10,000 hours exposure.

e. Meet ASTM B117 for salt spray with no more than 1% rust or plane, no more than 1/64 of an inch creep at scribe after 10,000 hours.

f. Meet ASTM D 4060 for abrasion with no more than 180 mg loss after 1,000 cycles.

g. Meet ASTM D 1014 for exposure with no blistering, cracking, checking, rusting, or delamination of film after 5-years of exposure.

h. Meet ASTM D 870 for immersion with no blistering, cracking, checking, rusting or delamination of film after 2-years of continuous water immersion.

i. Meet ASTM D 1653 for vapor transmission with no more than 9.9 g/m2 in 24 hours (transmission) and no more than 0.31 g/SF per hour in hg (permeability).

PART 3 - EXECUTION

3.1. EXPANSION JOINT INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

B. Install expansion joints in the “cold” position, such that when piping is in service, expansion joints can accept the maximum allowable expansion.

C. Do not weld/ground across expansion joints per manufacturer’s recommendation.

3.2. PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

B. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

C. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.3. ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install two guides on each side of pipe expansion fittings and loops.

C. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

D. Install guides nearest to expansion joint as indicated on drawings and recommended by the manufacturer.

E. Attach guides to pipe, and secure guides to building structure.

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

G. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

H. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.

2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

I. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 230516

SECTION 230517 – SLEEVES AND SLEEVE SEALS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes sleeves, sleeve seals and associated materials.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

PART 2 - PRODUCTS

2.1. SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

D. Galvanized-Steel-Sheet Sleeves: Minimum 20-gauge thickness; round tube closed with welded longitudinal joint.

E. PVC pipe sleeves are not acceptable.

2.2. SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing-element unit, designed for field-assembly for filling annular space between piping and sleeve. The sealing elements shall be interlocking links shaped to fit pipe surface. GPT Link-Seal or Engineer approved equal.

1. Piping Systems, 180 deg F and below:

a. Sealing Elements: EPDM-rubber or NBR (nitrile butadiene rubber).

b. Pressure Plates: Reinforced Nylon Polymer.

c. Connecting Bolts and Nuts: Stainless steel or carbon steel with corrosion resistance coating.

d. Constant Temperature Rating: 200 deg F.

B. PVC sleeve seal systems are not acceptable.

2.3. GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1. SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

1. Insulated piping systems shall have insulation continue through penetrations without interruption. Insulation joints shall not occur within sleeves.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch minimum annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and masonry walls as new slabs and walls are constructed.

1. Walls: Cut sleeves to length for mounting flush with both surfaces.

2. Floors: Extend sleeves 1-inch above finished floor and seal penetrations watertight.

3. Mechanical Equipment Room and Wet Area Floors: Extend sleeves 2-inches above finished floor and seal penetrations watertight.

4. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.

2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.

3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements of sealants.

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping and associated U.L. detail.

3.2. SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior masonry walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3. SLEEVE AND SLEEVE-SEAL SYSTEM SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Cast-Iron Pipe Sleeves with Sleeve Seal Systems: Masonry walls above and below grade and concrete slabs on grade.

    a. Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

2. Galvanized Steel Pipe Sleeves: Interior fire-rated partitions; interior non-rated partitions; and concrete slabs above grade.

3. Galvanized Steel Sheet Sleeves: Interior non-rated partitions.

END OF SECTION 230517

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SECTION 230519 – PIPING INSTRUMENTS AND GAGES

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes instruments and gages for HVAC systems.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1. Product Certificates: For each type of instrument and gage from manufacturer.

B. Close-Out Submittals:

1. Operation and Maintenance Data: For instruments and gages to include in operation and maintenance manuals.

1.3. QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

B. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

C. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

PART 2 - PRODUCTS

2.1. THERMOMETERS

A. Standard: ASME B40.200.

B. Liquid-in-Glass Thermometers: 9-inch cast aluminum case with adjustable angle; glass tube with magnifying lens and blue or red organic liquid; non-reflective aluminum with permanently etched

scale markings graduated in deg F and deg C; glass window; aluminum stem of length suitable for application for Thermowell installation; 1-1/4 inch connector with ASME B1.1 screw threads; and accuracy to plus or minus 1 percent of scale range.

C. Thermometer Scale Ranges for Piping Systems:

1. Chilled Water: 0 to 100 deg F.

2. Heating Water: 0 to 250 deg F.

D. Thermometer stems shall be of length to match thermowell insertion length.

2.2. THERMOWELLS

A. Standard: ASME B40.200.

B. Thermowells: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.

1. Material for Use with Copper Tubing: Copper-nickel (90-10) or copper-nickel (70-30).

2. Material for Use with Steel Piping: Corrosion resistant steel.

3. Type: Stepped shank unless straight or tapered shank is indicated.

4. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.

5. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.

6. Bore: Diameter required to match thermometer bulb or stem.

7. Insertion Length: Length required to match thermometer bulb or stem.

8. Lagging Extension: Include on thermowells for insulated piping and tubing.

9. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

C. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.3. PRESSURE GAGES

A. Standard: ASME B40.100.

B. Dial-Type Pressure Gages: Oil-filled, cast aluminum case with 4-1/2 inch nominal diameter; non-reflective aluminum dial with permanently etched scale markings graduated in psi and feet; bourdon

tube pressure element assembly; brass pressure connection with NPS 1/4 or 1/2 inch ASME B1.20 pipe threads and bottom-outlet; mechanical movement with link pressure element and connection to pointer; glass window; stainless steel ring; dark colored metal pointer; and accuracy to plus or minus 1 percent of scale range.

1. Pump shall be equipped with compound gages calibrated from full vacuum to the selected pressures.

C. Scale Ranges for Piping Systems:

1. Chilled Water: 0 to 100 psi.

2. Heating Water: 0 to 100 psi.

2.4. GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and surge-dampening device. Include extension for use on insulated piping.

B. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.5. TEST PLUGS

A. Test Plug: Test-station fitting made for insertion into piping tee fitting; brass or stainless steel body including extended stem when used on insulated piping; core inserts and gasketed and threaded cap; ASME B1.20.1 pipe threads; chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber core inserts; rated for a minimum of 500 psig at 200 deg F.

2.6. TEST-PLUG KITS

A. Furnish one test-plug kit containing two thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall match diameter to fit test plugs and of length to project into piping.

B. Low-Range Thermometer: Small, bimetallic insertion type with 2-inch diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F.

C. High-Range Thermometer: Small, bimetallic insertion type with 2-inch diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F.

D. Pressure Gage: Small, Bourdon-tube insertion type with 2-inch diameter dial and probe. Dial range shall be at least 0 to 200 psig.

E. Carrying Case: Metal or plastic, with formed instrument padding.

2.7. SIGHT FLOW INDICATORS

A. Sight Flow Indicators: Inline-installation device for visual verification of flow with sight glass and paddle wheel indicator; bronze or stainless-steel body; threaded end connections for NPS 2-inches and smaller and flanged end connections for NPS 2-1/2 inches and larger; and rated for minimum of 150 psig and 200 deg F.

PART 3 - EXECUTION

3.1. INSTALLATION

A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

I. Install remote-mounted pressure gages on panel.

J. Install valve and snubber in piping for each pressure gage.

K. Install test plugs in piping tees.

L. Install flow indicators in piping systems in accessible positions for easy viewing.

M. Install permanent indicators on walls or brackets in accessible and readable positions.

N. Install connection fittings in accessible locations for attachment to portable indicators.

O. Install thermometers in the inlet and outlet piping of each:

1. Hydronic boilers.
2. Chiller, chilled water connections.
3. Air-handling unit hydronic coils.

P. Install pressure gages in the inlet and outlet piping of each:

1. Pressure-reducing valves.
2. Chiller, chilled water connections.
3. Air handling unit hydronic coils.
4. Pumps.

Q. Install temperature and pressure test ports at each terminal unit reheat coil.

3.2. ADJUSTING

A. Adjust faces of instruments and gages to proper angle for best visibility.

END OF SECTION 230519

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SECTION 230529 – HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes pipe hangers and hanger shields, metal framing systems, fastener systems, pipe-stands and equipment supports.

1.2. PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.3. SUBMITTALS

A. Qualification Submittals: Welding certificates.

B. Product Submittals: For each type of product indicated.

1.4. QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1. METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports: MSS SP-58, Types 1 through 58, factory-fabricated components. Hangers shall be galvanized. Padded hangers shall be fiberglass pad or cushion to support bearing surface of piping. Hanger rods shall be continuously threaded with nuts and washers made of carbon steel.

B. Stainless-Steel Pipe Hangers and Supports: MSS SP-58, Types 1 through 58, factory-fabricated components. Padded hangers shall be fiberglass pad or cushion to support bearing surface of piping. Hanger rods shall be continuously threaded with nuts and washers made of stainless steel.

C. Copper Pipe Hangers: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components. Hanger rods shall be continuously threaded with nuts and washers made of stainless steel.

2.2. TRAPEZE PIPE HANGERS

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

2.3. METAL FRAMING SYSTEMS

A. Description: Shop or field-fabricated pipe-support assembly for supporting multiple parallel pipes. Channels shall be continuous slotted steel with in-turned lips. Channel nuts shall be designed to fit into channel slot and when tightened to prevent slipping. Hanger rods shall be continuously threaded with nuts and washers made of carbon steel.

2.4. THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength. For cold piping systems, include vapor barrier.

B. Insert and shield shall cover the entire pipe circumference for trapeze of clamped systems and cover the lower 180-degrees of pipe circumference for clevis or band hangers.

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

2.5. 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. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened Portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6. EQUIPMENT SUPPORTS

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

2.7. MISCELLANEOUS MATERIALS

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

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

1. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1. HANGER AND SUPPORT INSTALLATION

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

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

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

D. Fastener System Installation:

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

2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

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

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

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

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

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

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

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

L. Insulated Piping:

1. Attach clamps and spacers to piping. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping. Clamps may project through the insulation of hot piping systems. Use thermal hanger shield inserts with clamp sized to match outside diameter of insert for cold piping systems.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

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

a. Less than 4-inches NPS: 12-inches long and 0.060-inch thick.

b. 4 to 6-inches NPS: 18-inches long and 0.060-inch thick.

5. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2. EQUIPMENT SUPPORTS

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

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

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

3.3. METAL FABRICATIONS

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

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

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

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.

4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4. ADJUSTING

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

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

3.5. PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6. HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

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

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

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

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

F. Use stainless-steel pipe hangers and stainless-steel attachments for hostile environment applications.

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

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

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

J. Horizontal-Piping Hangers and Supports:

1. Adjustable Steel Clevis Hangers (MSS Type 1)

2. Split-Ring Hangers (MSS Type 69): Piping 2-inches NPS and smaller.

3. Copper Pipe Hangers: For copper piping.

K. Trapeze Pipe-Hangers: Trapeze hangers shall be welded carbon steel pre-formed structural members suspended by threaded rods. Comply with MSS SP-69. Each pipe shall be individually supported.

1. Adjustable Pipe Saddles (MSS Type 38)

2. Copper Pipe Saddles: For copper piping.

L. Vertical-Piping Clamps:

1. Riser Clamps (MSS Type 8)

M. Building Attachments: Install MSS compliant devices for all building attachments. Install them per manufacturer’s instructions.

N. Saddles and Shields:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.

2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.

3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.

2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.

3. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.

4. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.

5. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.

6. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.

7. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types: horizontal (MSS Type 54), vertical (MSS Type 55) or trapeze (MSS Type 56).

P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

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

3.7. PIPE HANGER INSTALLATION

A. Steel Piping: Install hangers for steel piping with the following minimum rod sizes and maximum spacing:

1. 1 1/4-inch NPS and smaller: 3/8-inch diameter at 7-foot span.

2. 1 1/2-inch NPS: 3/8-inch diameter at 9-foot span.

3. 2-inch NPS: 3/8-inch diameter at 10-foot span.

4. 2 1/2-inch NPS: 1/2-inch diameter at 10-foot span.

5. 3-inch NPS: 1/2-inch diameter at 12-foot span.

6. 4-inch NPS: 5/8-inch diameter at 12-foot span.

7. 6-inch NPS: 3/4-inch diameter at 12-foot span.

B. Copper Piping: Install hangers for drawn-temper copper piping with the following minimum rod sizes and maximum spacing:

1. 1 1/4-inch NPS and smaller: 3/8-inch diameter at 5-foot span.

2. 1 ½ to 2-inch NPS: 3/8-inch diameter at 8-foot span.

C. Support vertical runs at roof, at each floor, and at 8-foot intervals between floors.

END OF SECTION 230529

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SECTION 230533 – HEAT TRACING

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes heat tracing for HVAC piping with electric heating cables:

1.2. SUBMITTALS

A. Product Submittals: For each type of product include rated capacities, operating characteristics, and furnished specialties and accessories. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.

B. Close-Out Submittals:

1. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.

1.3. QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

B. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

C. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

1.4. WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Five (5) years from date of Owner Acceptance.

PART 2 - PRODUCTS

2.1. SELF-REGULATING PARALLEL-RESISTANCE HEATING CABLES

A. Comply with IEEE 515.1.

B. Heating Element: Pair of parallel No. 16 AWG, nickel-coated, stranded copper bus wires embedded in cross-linked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled, non-heating leads with connectors at one end,

and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

C. Electrical Insulating Jacket: Flame-retardant polyolefin.

D. Cable Cover: Stainless-steel braid and polyolefin outer jacket with ultraviolet inhibitor.

E. Temperature Performance:

1. Start-up temperature: 20 deg F worst case after power loss.

2. Piping Systems Operating at maximum 120 deg F:

a. Maximum Operating Temperature (Power On): 150 deg F.

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

3. Piping Systems Operating at 121 deg F to 211 deg F:

a. Maximum Operating Temperature (Power On): 230 deg F.

b. Maximum Exposure Temperature (Power Off): 275 deg F.

F. 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. Coordinate the voltage and phase requirements with the electrical documents.

G. Capacities and Characteristics: Provide the number and rating of heating cables appropriately sized for their intended use but not less than 5 W/LF.

2.2. CONTROLS

A. Operational Controls:

1. Remote bulb unit with adjustable temperature range from 30 to 50 deg F.

2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.

3. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.

4. Corrosion-resistant, waterproof control enclosure.

5. Built in, 30 ma ground fault protection.

2.3. ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick and minimum 3/4-inch wide with pressure-sensitive, permanent, waterproof, self-adhesive back.

C. Pilot Light: LED pilot light that is energized when the heating elements are energized. LED pilot light shall be provided for all end seals.

PART 3 - EXECUTION

3.1. EXAMINATION

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

1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.

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

3.2. INSTALLATION

A. Install heat tracing on all outside above-ground water piping, tanks and water equipment to prevent freezing. Refer to drawings for more information.

B. Install electric heating cable across expansion joints according to manufacturer's written instructions; use slack cable to allow movement without damage to cable.

C. Install electric heating cables after piping has been tested and before insulation is installed.

D. Install electric heating cables according to IEEE 515.1.

E. Install insulation over piping with electric cables according to Section 230719 "HVAC Piping Insulation."

F. If splices are necessary, install such that they are not covered under the pipe insulation.

G. Install warning tape on piping insulation jacket where piping is equipped with electric heating cables. Locate warning tape every 10 feet.

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

3.3. CONNECTIONS

A. Ground equipment and connect wiring according to Division 26.

3.4. FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.

2. Test cables for electrical continuity and insulation integrity before energizing.

3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

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

3.5. PROTECTION

A. Protect installed heating cables, including non-heating leads, from damage during construction.

B. Remove and replace damaged heat-tracing cables.

END OF SECTION 230533

SECTION 230548 – HVAC SEISMIC, WIND AND VIBRATION CONTROLS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes vibration control devices and related materials, including isolators, mounts, guides and supports.

B. Description: Delegated design of all equipment and materials installed under Division 23.

1. Vibration Isolation: Applies to all HVAC equipment and materials.

1.2. SUBMITTALS

A. Delegated-Design Submittals: For each vibration isolation device:

1. Include design calculations and details for selecting vibration isolators, and vibration isolation materials complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer (registered in the state of the project's location) responsible for their preparation.

B. Product Submittals: For each type of product indicated.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device required.

1.3. QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1. MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide product by one of the following for spring and elastomeric isolators:

1. Mason Industries, Inc.

2. Kinetics Noise Control, Inc.

3. Vibration Eliminator Company, Inc.

4. Vibration Mounting & Controls (VMC) Group, Inc.

2.2. PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Ultimate Wind Speed: 129 MPH.

2. Building Risk Category: III.

3. Minimum 50 lb/sq. ft. multiplied by maximum area of HVAC component projected on vertical plane normal to wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the State Building Code: D.

2. Seismic Design Category: B.

3. Assigned Risk Category as Defined in the State Building Code: III.

a. Component Importance Factor of 1.5:

1) Life-Safety Dampers

2) Fire Protection Systems

3) Natural Gas, Propane (LP) Gas, and Fuel Oil Piping Systems

4) Carbon Monoxide Detection and Alarm Systems

5) Fuel-Fired Equipment Chimneys and Breechings

b. Component Importance Factor of 1.0: All other systems and their components.

c. Component Response Modification Factor: Table 13.6-1, ASCE 7-10 - Chapter 13.

d. Component Amplification Factor: Table 13.6-1, ASCE 7-10 - Chapter 13.

4. Design Spectral Response Acceleration at Short Periods (0.2 Second): 0.163.

5. Design Spectral Response Acceleration at 1.0-Second Period: 0.118.

6. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they are subjected.

2.3. ELASTOMERIC ISOLATION PADS

A. Description: Elastomeric Isolation Pads.

1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.

2. Size: Factory or field cut to match requirements of supported equipment.

3. Pad Material: Oil and water resistant with elastomeric properties.

4. Surface Pattern: Waffle pattern.

5. Infused nonwoven cotton or synthetic fibers.

6. Load-bearing metal plates adhered to pads.

7. Sandwich-Core Material: Resilient and elastomeric.

a. Surface Pattern: Waffle pattern.

b. Infused nonwoven cotton or synthetic fibers.

2.4. ELASTOMERIC ISOLATION MOUNTS

A. Description: Double-Deflection, Elastomeric Isolation Mounts.

1. Mounting Plates:

a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.

b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

2. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5. RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

1. Housing: Cast-ductile iron or welded steel.

2. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.6. OPEN SPRING ISOLATORS

A. Description: Freestanding, Laterally Stable, Open-Spring Isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

2. Minimum Additional Travel: 50 percent of the required deflection at rated load.

3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

5. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig.

6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.7. HOUSED SPRING ISOLATORS

A. Description: Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

2. Minimum Additional Travel: 50 percent of the required deflection at rated load.

3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

5. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.

2.8. RESTRAINED SPRING ISOLATORS

A. Description: Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint.

1. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.

b. Top plate with threaded mounting holes or elastomeric pad.

c. Internal leveling bolt that acts as blocking during installation.

2. Restraint: Limit stop as required for equipment and authorities having jurisdiction.

3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

4. Minimum Additional Travel: 50 percent of the required deflection at rated load.

5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.9. HOUSED RESTRAINED SPRING ISOLATORS

A. Description: Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing.

1. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.

a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.

b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.10. PIPE RISER RESILIENT SUPPORTS

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch thick neoprene.

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.

2. Maximum Load Per Support: 500 psig on isolation material providing equal isolation in all directions.

2.11. RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch-thick neoprene.

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and re-insertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.12. ELASTOMERIC HANGERS

A. Description: Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods.

1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.

2. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.13. SPRING HANGERS

A. Description: Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.

7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.

8. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.14. SNUBBERS

A. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.

2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.

3. Maximum 1/4-inch air gap, and minimum 1/4-inch-thick resilient cushion.

2.15. RESTRAINT CHANNEL BRACINGS

A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.16. RESTRAINT CABLES

A. Restraint Cables: ASTM A 492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.17. MECHANICAL ANCHOR BOLTS

A. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.18. ADHESIVE ANCHOR BOLTS

A. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1. EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic and wind control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2. APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Vibration Isolation: In addition to vibration isolation devices indicated within the project documents, provide isolators per ASHRAE Handbook – "HVAC Applications", Chapter 49, Table 47 "Selection Guide for Vibration Isolation".

1. Install vibration isolators on all vibrating equipment.

2. Suspended Piping: Install vibration isolation hangers in all mechanical equipment rooms and on all piping within 50 feet of vibrating equipment connections.

a. Three hangers closest to each equipment connection shall be rated for deflection equal to the equipment isolator deflection.

b. The remaining hangers shall have a deflection of 3/4-inch.

c. Exceptions: Not required at terminal equipment connections where the equipment is isolated, such as terminal units, blower coil units, fan coil units and heaters.

3. Noise Sensitive Spaces: All piping 2-inches and larger and ductwork within 50-feet of spaces designated as noise sensitive shall have vibration isolation hangers.

3.3. CONTROL AND RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork.

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Equipment Restraints:

1. Install snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.

2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

D. Piping Restraints:

1. Comply with requirements in MSS SP-127.

2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.

3. Brace a change of direction longer than 12 feet.

E. Install cables so they do not bend across edges of adjacent equipment or building structure.

F. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

I. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

5. Set anchors to manufacturer's recommended torque, using a torque wrench.

6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4. FIELD QUALITY CONTROL

A. Perform tests and inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Engineer.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.5. ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

END OF SECTION 230548

SECTION 230553 – HVAC SYSTEMS IDENTIFICATION

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes equipment, pipe and duct labels and tags.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1. Product Data: For each type of product indicated.

2. Samples: For color, letter style, and graphic representation required for each identification material and device.

B. Close-Out Submittals:

1. Valve Schedules: For each piping system to include in maintenance manuals.

1.3. COORDINATION

A. Coordinate the identification requirements with the Owner’s up-to-date standards prior to purchasing materials.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with locations of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1. EQUIPMENT LABELS

A. Plastic Labels for Equipment: 1/8-inch multilayer, multicolor, plastic labels for mechanical engraving suitable for temperatures up to 160 deg F with pre-drilled holes for stainless steel rivets or self-tapping screws. Labels shall be minimum 2-1/2 inches wide and 3/4-inch tall with 3/8-inch white letters on black background.

1. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's drawing designation or unique equipment number.

2.2. WARNING SIGNS AND LABELS

A. Warning Signs and Labels: 1/8-inch multilayer, multicolor, plastic labels for mechanical engraving suitable for temperatures up to 160 deg F with pre-drilled holes for stainless steel rivets or self-tapping screws. Labels shall be minimum 2-1/2 inches wide and 3/4-inch tall with 3/8-inch letters.

1. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3. PIPE LABELS

A. Pipe Labels: Pre-printed, color-coded, self-adhesive vinyl labels with lettering and flow direction arrows. They shall have minimum 1 1/2-inch tall block lettering. The labels shall be suitable for temperatures up to 160 deg F and compatible with each substrate material.

2.4. DUCT LABELS

A. Duct Labels: Stenciled labels, showing service and flow direction. They shall have minimum 1 1/2-inch tall block lettering.

2.5. STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; 3/4-inch for rated penetrations, and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions. Stencil paint shall be exterior, gloss, acrylic enamel.

2.6. VALVE TAGS

A. Valve Tags: 0.032-inch thick brass or 0.025-inch thick stainless steel, stamped or engraved, with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers with pre-drilled or stamped holes for beaded chain attachment hardware.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.7. DRYER VENT LENGTH IDENTIFICATION

A. Dryer Vents: Labels shall be permanently stenciled, laminated, or commercially available plastic or metal tags.

B. Provide labels for each dryer vent installation, labels shall state the following, at a minimum:

1. Caution: Equivalent Length (indicated equivalent length for each vent) feet. Any dryer installed must be equipped with an exhaust system that meets or exceeds this equivalent length requirement.

2.8. CEILING TAGS

A. Ceiling Tags: 0.030-inch thick and 3/4 to 7/8-inch diameter rigid vinyl, self-adhesive, plastic tags with pre-printed, minimum 1/8-inch tall block-letter text indicating the service, equipment, valve or accessory tag and number designations.

2.9. WARNING TAGS

A. Warning Tags: 5-1/4 inches wide and 3-inches tall, pre-printed or partially pre-printed, accident-prevention tags, of plasticized card stock with matte finish suitable for writing, fastened with reinforced grommet and wire. Tags shall have letters with large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

2.10. SENSOR TAGS

A. Sensor Tags: 1/4-inch wide, pre-printed, clear vinyl adhesive tags with 1/8-inch tall block-letter black text. Each sensor shall be clearly and neatly labelled. Tags shall denote the associated piece of equipment, for example “TU-123”.

PART 3 - EXECUTION

3.1. PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulates.

3.2. JACKET COLOR

A. Piping and Piped Equipment Insulation Jacket: Paint or provided pre-colored jacketing for all piping system insulation jacket meeting the requirements of this section.

1. P/M/E Equipment Rooms: 30 mils thick PVC; pre-colored per System Identification Schedule.

2. Exposed-to-View in Occupied Spaces: Woven glass-fiber fabric jacket, painted to match adjacent surfaces.

3. Partially Exposed-to-View Above Floating Ceilings: ASJ jacket, painted flat black.

4. Concealed: Not required.

B. Duct and Ducted Equipment Insulation Jacket: Paint or provided pre-colored jacketing for all duct system insulation jacket meeting the requirements of this section.

1. PME Equipment Rooms: White woven glass-fiber fabric jacket.

2. Exposed-to-View in Occupied Spaces: Double wall duct; paint to match adjacent surfaces.

3. Partially Exposed-to-View Above Floating Ceilings: ASJ jacket, painted flat black.

4. Concealed: Not required.

3.3. PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.

2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.

3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.

4. At access doors, manholes, and similar access points that permit view of concealed piping.

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

6. Spaced at maximum intervals of 25 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.

7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

3.4. EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment. Equipment to be labelled includes but is not limited to:

1. Air handling equipment, including AHU, BCU, ERU, etc.

2. Fans.

3. Terminal units.

4. Split-systems; at both indoor and outdoor units.

5. Hydronic equipment, including pumps, water treatment, tanks and separators.

6. Boilers.

7. Chillers.

8. Unit heaters.

9. Flow and energy meters.

10. Control panels and main sensors.

11. Variable speed controllers, motor starters and disconnects.

    a. Coordinate labeling with Division 26.

B. Central HVAC system equipment labels shall include capacity and design information. Submit proposed label information for Engineer approval. The following are examples:

1. Chillers

   CHILLER CH-1
   INSTALLED: JUNE 2030
   CAPACITY: 500 TONS
   CHW FLOW: 1200 GPM

2. Boilers

   BOILER B-1
   INSTALLED: JUNE 2030
   OUTPUT: 1600 MBH
   INPUT: 2000 MBH
   HHW FLOW: 160 GPM
   HHW TEMPS: 160F / 180F

3. Air Handling Units

   AIR HANDLING UNIT AHU-1
   INSTALLED: JUNE 2030
   SERVICE: CLASSROOM WING A
   CAPACITY: 10,000 CFM at 2.0" ESP
   COOLING: 25 TONS
   HEATING: 400 MBH

4. Fans

   EXHAUST FAN EF-1
   INSTALLED: JUNE 2030
   SERVICE: ROOMS E101, E102, and E103
   CAPACITY: 500 CFM at 0.5" ESP

C. Locate equipment labels where accessible and visible.

3.5. DUCT LABEL INSTALLATION

A. Stenciled Duct Labels: Stenciled labels, showing service and flow direction.

B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 25 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.6. VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

3.7. CEILING TAG INSTALLATION

A. Install ceiling tags on lay-in grid and access doors below equipment, valves and accessories above finished ceilings. Center tags on grid members and doors.

3.8. WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

3.9. SENSOR TAG INSTALLATION

A. Install sensor tags for wall or ceiling-mounted sensors on faceplates centered below the device. Install sensor tags for concealed sensors on sensor enclosures or backboxes. Where sensors are located above lay-in ceilings, behind access doors, or otherwise remotely accessible, label the grid or door in addition to the device itself. Tags shall be centered and neatly applied.

3.10. RATED PENETRATION INSTALLATION

A. Stencil penetration ratings and UL detail numbers on wall surfaces directly adjacent to the penetrations. UL detail number shall match the material used. This information shall be readily visible in non-occupied spaces, within chases and above ceilings. The following is an example:

2-HR RATED FIRE BARRIER
UL DETAIL SYSTEM NO. ABC-0000

3.11. SYSTEM IDENTIFICATION SCHEDULE

A. Install equipment, piping and duct identification materials with the color and abbreviations that match the Owner’s standard practice. Refer to System Identification Schedule below.

SYSTEM IDENTIFICATION SCHEDULE				
PIPING SYSTEMS	**ABBREV.**	**BACKGROUND**	**LETTERING**	**JACKET COLOR**
CHILLED WATER	CHWS/CHWR	GREEN	WHITE	MEDIUM BLUE
REFRIGERANT	REF	GREEN	WHITE	BLACK
HEATING WATER	HWS/HWR	GREEN	WHITE	MEDIUM RED
NATURAL GAS	NG	YELLOW	BLACK	YELLOW
OTHERS	SEE PLANS	WHITE	BLACK	
VALVE TAGS		BRASS	BLACK	
EQUIPMENT AND DUCT SYSTEMS	**ABBREV.**	**BACKGROUND**	**LETTERING**	**JACKET COLOR**
GENERAL BUILDING AIR	SA/RA/EA/OA	WHITE	BLACK	PAINTED
WARNING SIGNS	SEE PLANS	SAFETY YELLOW	BLACK	
EQUIPMENT TAGS	SEE PLANS	BLACK	WHITE	
CEILING GRID MARKERS			**TAG**	
MECHANICAL EQUIPMENT, FAN, DAMPERS, ETC.			NEON YELLOW	
CHILLED WATER VALVES			BLUE	
HEATING HOT WATER VALVES			GREEN	
DOMESTIC COLD WATER VALVES, ARRESTORS, ETC.			BLUE	
DOMSETIC HOT WATER VALVES			GREEN	
GAS VALVES, REGULATORS, ETC.			YELLOW	
ELECTRICAL EQUIPMENT, PULL BOXES, DISCONNECTS, ETC.			NEON RED	
FIRE ALARM, SPRINKLERS, LIFE SAFETY EQUIPMENT, VALVES, ETC.			RED	

NOTES:

1. PROVIDE FLOW ARROWS ON ALL DUCT AND PIPE MARKERS.
2. NATURAL GAS PIPING LABELS SHALL INCLUDE LINE PRESSURE.
3. PIPE LABEL COLORS PER ASME A13.1.

END OF SECTION 230553

SECTION 230555 – HVAC PIPING SYSTEMS FLUSHING AND TESTING

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes requirements for HVAC piping system flushing and testing.

1.2. SUBMITTALS

A. Delegated Design Submittals:

1. Flushing and Testing Plan: Submit a Flushing and Testing Plan for review and approval of the Engineer. The plan shall include proposed use of building and temporary equipment; extent of piping system to be flushed and tested in each phase, if not performed all at once; source of water; disposal of water; flow rates; temporary bypass details and chemicals; etc.

B. Product Submittals: For each type of product indicated include rated capacities, operating characteristics, and furnished specialties and accessories.

C. Construction Submittals:

1. Flushing and Testing Field Reports: For each section of piping that is independently flushed and tested, provide a letter to the Engineer certifying that the flushing and testing was performed in accordance to the requirements; documenting the failures and corrective actions; and recording the final results. Each letter shall be signed and dated by the Mechanical Contractor's Representative who performed the tests and the General Contractor' Representative who witness the tests certifying the piping system is clean and leak-free. A plan of the piping systems with sections flushed and tested highlighted shall be attached to each letter. The flushing and testing schedule shall be coordinated with the Owner and Engineer.

D. Close-Out Submittals:

1. Flushing and Testing Summary: Submit a copy of the Flushing and Testing Plan with any changes required by field conditions; a copy of each Flushing and Testing Field Report; and a Final Flushing and Testing Field Report that certifies that all applicable sections of each piping system have been satisfactorily completed.

PART 2 - PRODUCTS

2.1. TEMPORARY EQUIPMENT AND MATERIALS

A. Provide all temporary equipment and materials required to perform the flushing and testing procedures.

1. Use of building pumps is prohibited.

B. Circulation pumps shall be sized and equipped with a variable speed drive and a flow meter so that the minimum flow velocity of 6 feet/second can be maintained in all tested pipe sizes. Use each pipe size's interior diameter to calculate the minimum flow rate in gallons/minute to determine the equivalent velocities.

C. Temporary materials shall match the permanent materials unless a substitution is approved by the Engineer.

1. Exception: Stainless steel corrugated flexible hoses with stainless steel braided covers rated for pressures in excess of the test pressures may be used for 2-inch and smaller temporary piping bypasses. Hoses must be free of kinks and sharp bends that could prevent proper circulation or restrict flushing of debris.

PART 3 - EXECUTION

3.1. TEMPORARY CONNECTIONS

A. Heating and Cooling Equipment: At each heating and cooling equipment connection, provide a bypass to isolate the equipment and associated control and balancing valves from the piping.

1. Upon completion of the piping mains and branches up to and including the equipment isolation valves; prior to installing the equipment control and balancing valve assemblies; and prior to installing the pipe insulation, install temporary bypass piping from the supply to the return branches. The bypass shall be of the same size and material as the branch piping. When open, the isolation valves shall allow the flushing and testing procedures. When closed, the isolation valves shall allow the bypass piping to be removed without exposing the completed piping sections.

2. Upon acceptance of piping section, remove the temporary bypasses and complete installation of equipment valve assemblies and equipment connections.

B. Maintain isolation between accepted and unaccepted piping at all times. If accepted piping is exposed to water circulated through unaccepted piping or any other dirt and debris, then the affected sections shall be re-flushed and tested as determined by the Engineer.

C. If accepted piping is modified, then the affected sections shall be re-flushed and tested.

3.2. HYDRONIC PIPING SYSTEM FLUSHING AND TESTING PROCEDURES

A. Prior to start, verify weld inspections and testing is complete as required in Section 230100.

B. Initial Flushing:

1. Install temporary equipment and piping required to perform flushing.

2. Fill piping system with clean water and vent air.

3. Install initial basket screens in circulation pump strainer. Circulate water and clean out strainer periodically until the initial basket screen remains clean for 30 minutes minimum. Insert final fine grit basket screen. Circulate water and clean out strainer periodically until the final basket screen remains clean for 30 minutes minimum.

4. Upon completion of initial flushing, drain water to sanitary sewer and replace strainer basket screens.

C. Pressure and Leak Testing:

1. Conduct pressure and leak testing after the initial flushing and prior to the final flushing of the system.

2. Conduct pressure and leak testing prior to insulating the piping.

3. Prior to testing, verify the maximum test pressure and duration of piping system components with their manufacturer. Do not test piping systems at pressures and durations in excess of the manufacturer’s recommendations.

4. Prepare hydronic piping for testing according to ASME B31.9 and as follows:

a. Leave joints, including welds, uninsulated and exposed for examination during test.

b. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.

c. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.

d. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

e. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

f. Fill piping system with clean water.

g. Remove air from the piping using air vents at all high points in the system. Where air vents have not been installed yet because the final high point will be a part of the equipment valve assembly and connection piping, install manual air vent at the highest point in the temporary bypass piping.

h. Isolate expansion tanks and determine that hydronic system is full of water.

D. Perform the following tests on hydronic piping:

1. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's maximum working pressure but not less than 100 psig. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."

a. Refer to Section 232113 and 232133 for hydronic and makeup water piping system operating pressures.

2. After hydrostatic test pressure has been applied for at least 15 minutes, examine piping, joints, and connections for leakage. Eliminate leaks and repeat hydrostatic test until there are no leaks for a continuous 4 hours.

   a. Verify the test pressure does not drop over the duration of the test. Do not perform tests when the ambient temperature rises or drops enough to affect the test pressure.

   b. If the piping fails, identify the leakage points, cut out the non-compliant sections and replace them with new materials. Do not attempt to patch, epoxy or caulk leaks.

3. Record results.

4. Upon completion of testing, drain water to sanitary sewer. Use drains installed at low points for complete draining of test liquid.

5. Prepare written report of testing.

6. Upon completion of testing, insulating work may begin.

E. Cleaning and Final Flushing:

1. Fill piping system with clean water and vent air.

2. Add pre-cleaning chemical solution designed to remove construction deposits such as pipe dope, oils, loose scale and other materials at manufacturer's recommended ratios. Circulate for 4 hours minimum and drain to sanitary sewer. Refill and re-flush until the system water is within the following tolerances of the makeup (utility service) water:

    a. Alkalinity: 0.3 pH

    b. Conductivity: 20 micro-ohms

    c. No visible signs of cleaner or contaminates.

3. Fill piping system with clean water and vent air.

4. Add cleaning solution diluted at manufacturer's recommended ratios to effectively clean the piping surfaces but avoid decay of the surface materials. Cleaners with trisodium phosphate are prohibited. Neutralizer agents as recommended by the cleaner manufacturer shall be used.

5. Circulate water and clean out strainer periodically until the basket screen remains clean for 24 hours minimum.

6. Upon completion of final flushing and cleaning, drain water to sanitary sewer.

7. Refill with clean water, vent air and circulate water for 1 hour minimum. Drain water to sanitary sewer.

8. Refill with clean water and treat per Section 232500.

a. If the piping will be isolated from the system for more than 7 days, add corrosion inhibitor, NALCO 3DT279 or equal.

b. If the piping system will be connected to a central utility distribution system, then coordinate the final fill and chemical treatment with the Owner.

9. Remove temporary equipment and piping.

END OF SECTION 230555

SECTION 230593 – TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes testing, adjusting and balancing (TAB) of building systems.

1.2. GENERAL DESCRIPTION

A. HVAC Air Systems:

1. Verify duct leakage tests and results.

2. TAB of new HVAC air systems including supply, return, exhaust, relief and outside air to design requirements.

B. HVAC Piping Systems:

1. Verify pipe leakage tests and results.

2. TAB of new HVAC piping systems including heating water, chilled water, and refrigerant to design requirements.

C. HVAC Control Systems:

1. Verify new HVAC control systems.

D. Plumbing Piping Systems:

1. TAB of new plumbing systems including domestic hot water recirculation to design requirements.

E. Sound Testing:

1. Sound levels of air-cooled chiller / cooling tower at points indicated, including 30 feet from the unit in each direction, at the closest building wall of a normally occupied space, and at the closest point along the property line.

2. Sound levels of noise in acoustically sensitive spaces (Band and Music Classrooms. Media Center; Administrative Office Suite).

F. Vibration Testing:

1. Vibration levels of equipment above vibration sensitive spaces (air handling units located on elevated floors above occupied spaces).

1.3. SUBMITTALS

A. Qualification Submittals:

1. Qualification Data: Within 30 days of the Notice to Proceed, submit documentation that the TAB contractor and the project's TAB team members meet the qualifications specified in "Quality Assurance".

2. Instrument calibration reports, to include the following: instrument type and make; serial number; application; dates of use; and dates of calibration.

B. Product Submittals: For each type of product indicated.

C. Construction Submittals:

1. Initial certified TAB reports of individual systems for engineer's review.

2. Commissioning Agent Certification: Provide owner's commissioning agent's certification that TAB measurements have been sampled and are considered accurate.

D. Close-Out Submittals: Final certified TAB report with all systems in a single report.

1.4. QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by the Associated Air Balance Council (AABC).

1. TAB Field Supervisor: TAB contractor employee who is certified by AABC.

2. TAB Technician: TAB contractor employee who is certified by AABC.

B. TAB Conference: Meet with engineer, owner, construction manager, owner's commissioning agent and related sub-contractors regarding the approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide 30-day notice of scheduled meeting time and location.

1. Agenda Items:

a. The Contract Documents examination report.

b. The TAB Plan.

c. Coordination and cooperation of trades and subcontractors.

d. Coordination of documentation and communication flow.

C. TAB Certification: Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.

2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard AABC report forms as reviewed by the engineer.

E. TAB Instrumentation: Provide instrumentation certification report including equipment type and make, serial number, accuracy and calibration as described in ASHRAE-111, Section 5, "Instrumentation."

1. All instruments shall be calibrated within 6 months of use.

F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing" and ASHRAE 90.1, Section 6.7.2.3 - "System Balancing".

G. Code and AHJ Compliance: Comply with governing codes and requirements of authorities having jurisdiction.

1.5. PROJECT CONDITIONS

A. Partial Owner Occupancy: Owner may occupy completed areas of building before Owner Acceptance. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.6. COORDINATION

A. Notice: Provide 10-day notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on air and hydronic systems have been satisfactorily completed. Alterations of the systems due to incomplete or non-conforming work made after testing will void previous TAB results and require new testing at no additional cost to the owner or engineer. Verify related work is complete before starting.

1. Duct pressure tested without duct accessories such as dampers and access doors installed is not valid.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1. EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.

Q. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2. PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures including a list of each piece of equipment and system.

B. Complete system-readiness checks and prepare reports. Verify the following:

1. General:

a. Permanent electrical-power wiring is complete.

b. Automatic temperature-control systems are operational.

c. Equipment and duct access doors are securely closed.

d. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.

e. Windows and doors can be closed so indicated conditions for system operations can be met.

2. HVAC Air Systems:

a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.

b. Duct systems are complete with terminals installed.

c. Volume, smoke, and fire dampers are open and functional.

d. Clean filters are installed.

e. Fans are operating, free of vibration, and rotating in correct direction.

f. Variable-frequency controllers startup is complete and safeties are verified.

g. Automatic temperature-control systems are operational.

h. Ceilings are installed.

i. Windows and doors are installed.

j. Suitable access to balancing devices and equipment is provided.

3. HVAC Piping Systems:

a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.

b. Piping is complete with terminals installed.

c. Water treatment is complete.

d. Systems are flushed, filled, and air purged.

e. Strainers are pulled and cleaned.

f. Control valves are functioning in accordance with the sequence of operation.

g. Shutoff and balance valves have been verified to be 100 percent open.

h. Pumps are started and proper rotation is verified.

i. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.

j. Variable-frequency controllers startup is complete and safeties are verified.

k. Suitable access to balancing devices and equipment is provided.

3.3. GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in ASHRAE-111 and in this Section.

1. Comply with requirements in ASHRAE-62.1, Section-7.2.2 - "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300.

2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to specifications.

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4. GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Coordinate pullies and sheaves needed to balance applicable air systems with fan supplier. Refer to Section 233400.

E. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

F. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

G. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

H. Verify that motor starters are equipped with properly sized thermal protection.

I. Check dampers for proper position to achieve desired airflow path.

J. Check for airflow blockages.

K. Check condensate drains for proper connections and functioning.

L. Check for proper sealing of air-handling-unit components.

M. Verify that air duct system is sealed as specified.

3.5. PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:

    a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.

    b. Measure static pressure directly at the fan outlet.

    c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.

    d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

    a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.

5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure airflow of submain and branch ducts.

    a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.

3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.

2. Adjust patterns of adjustable outlets for proper distribution without drafts.

E. Verify final system conditions:

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.

2. Re-measure and confirm that total airflow is within design.

3. Re-measure all final fan operating data, speed, volts, amps, and static profile.

4. Mark all final settings.

5. Test system in economizer mode. Verify proper operation and adjust if necessary.

6. Measure and record all operating data.

7. Record final fan-performance data.

3.6. PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.

2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.

3. Measure total system airflow. Adjust to within indicated airflow.

4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.

5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Minimum airflow shall be not be below the minimum airflow requirements of the system for proper operation. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

6. Re-measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

    a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.

8. Record final fan-performance data.

B. Single-Zone, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Balance variable-air-volume systems the same as described for constant-volume air systems.

2. Set supply fan at minimum airflow if minimum airflow is indicated. Minimum airflow shall be not be below the minimum airflow requirements of the system for proper operation.

3. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.

4. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

5. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

3.7. COMMERCIAL KITCHEN EXHAUST SYSTEMS

A. Commercial Kitchen Exhaust Air Flow Certification: All exhaust systems serving commercial cooking appliances shall verify the flow rates meet the design criteria.

B. Commercial Kitchen Exhaust Hood Certification: Test hood capture and containment as installed with operating kitchen equipment. Use and observe steam / smoke visual testing. Video record preliminary successful results prior to final observation and acceptance by the Engineer and Authority Having Jurisdiction (AHJ).

3.8. GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed specified tolerance limits.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.

2. Check liquid level in expansion tank.

3. Check makeup water-station pressure gage for adequate pressure for highest vent.

4. Check flow-control valves for specified sequence of operation and set at indicated flow.

5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.

6. Set system controls so automatic valves are wide open to heat exchangers.

7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.

8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

D. Measure and record upstream and downstream pressure of each piece of equipment.

E. Measure and record upstream and downstream pressure of pressure-reducing valves.

F. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.

G. Check settings and operation of each safety valve. Record settings.

3.9. PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design flow.

1. Measure total water flow.

a. Position valves for full flow through coils.

b. Measure flow by main flow meter, if installed.

c. If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.

2. Measure pump TDH as follows:

a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.

b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.

c. Convert pressure to head and correct for differences in gauge heights.

d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to re-duce excess throttling.

3. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

B. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.

2. Adjust main and branch balance valves for design flow.

3. Re-measure each main and branch after all have been adjusted.

C. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.

2. Adjust each terminal to design flow.

3. Re-measure each terminal after it is adjusted.

4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.

5. Perform temperature tests after flows have been balanced.

D. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.

2. Perform temperature tests after flows have been verified.

E. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.

2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

F. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.

2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.

3. Mark final settings.

G. Verify that memory stops have been set.

3.10. PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the pressure-differential sensor(s) is located as indicated.

2. Determine whether there is diversity in the system.

C. For systems with no flow diversity:

1. Adjust pumps to deliver total design flow.

a. Measure total water flow.

1) Position valves for full flow through coils.

2) Measure flow by main flow meter, if installed.

3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.

b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.

2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strain-ers.

3) Convert pressure to head and correct for differences in gauge heights.

4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

2. Adjust flow-measuring devices installed in mains and branches to design water flows.

a. Measure flow in main and branch pipes.

b. Adjust main and branch balance valves for design flow.

c. Re-measure each main and branch after all have been adjusted.

3. Adjust flow-measuring devices installed at terminals for each space to design water flows.

a. Measure flow at terminals.

b. Adjust each terminal to design flow.

c. Re-measure each terminal after it is adjusted.

d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.

e. Perform temperature tests after flows have been balanced.

4. For systems with pressure-independent valves at terminals:

a. Measure differential pressure and verify that it is within manufacturer's specified range.

b. Perform temperature tests after flows have been verified.

5. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.

b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

6. Prior to verifying final system conditions, determine the system pressure-differential set point(s).

7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.

8. Mark final settings and verify that all memory stops have been set.

9. Verify final system conditions as follows:

a. Re-measure and confirm that total flow is within design.

b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.

c. Mark final settings.

D. For systems with flow diversity:

1. Determine diversity factor.

2. Simulate system diversity by closing required number of control valves, as approved by Architect.

3. Adjust pumps to deliver total design flow.

a. Measure total water flow.

1) Position valves for full flow through coils.

2) Measure flow by main flow meter, if installed.

3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.

b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.

2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.

3) Convert pressure to head and correct for differences in gauge heights.

4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

4. Adjust flow-measuring devices installed in mains and branches to design water flows.

   a. Measure flow in main and branch pipes.

   b. Adjust main and branch balance valves for design flow.

   c. Re-measure each main and branch after all have been adjusted.

5. Adjust flow-measuring devices installed at terminals for each space to design water flows.

   a. Measure flow at terminals.

   b. Adjust each terminal to design flow.

   c. Re-measure each terminal after it is adjusted.

   d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.

   e. Perform temperature tests after flows have been balanced.

6. For systems with pressure-independent valves at terminals:

   a. Measure differential pressure and verify that it is within manufacturer's specified range.

   b. Perform temperature tests after flows have been verified.

7. For systems without pressure-independent valves or flow-measuring devices at terminals:

   a. Measure and balance coils by either coil pressure drop or temperature method.

   b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.

9. Prior to verifying final system conditions, determine system pressure-differential set point(s).

10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.

11. Mark final settings and verify that memory stops have been set.

12. Verify final system conditions as follows:

    a. Re-measure and confirm that total water flow is within design.

    b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.

    c. Mark final settings.

3.11. PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first and then balance the secondary circuits.

B. Adjust pumps to deliver total design flow.

1. Measure total water flow.

a. Position valves for full flow through coils.

b. Measure flow by main flow meter, if installed.

c. If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.

2. Measure pump TDH as follows:

a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.

b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.

c. Convert pressure to head and correct for differences in gauge heights.

d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

e. With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

3. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

C. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.

2. Adjust main and branch balance valves for design flow.

3. Re-measure each main and branch after all have been adjusted.

D. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.

2. Adjust each terminal to design flow.

3. Re-measure each terminal after it is adjusted.

4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.

5. Perform temperature tests after flows have been balanced.

E. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.

2. Perform temperature tests after flows have been verified.

F. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.

2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

G. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.

2. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.

3. Mark final settings.

H. Verify that memory stops have been set.

3.12. PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.

2. Motor horsepower rating.

3. Motor rpm.

4. Efficiency rating.

5. Nameplate and measured voltage, each phase.

6. Nameplate and measured amperage, each phase.

7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.13. PROCEDURES FOR AIR-COOLED CHILLERS

A. Air-Cooled Chillers: Balance water flow through each evaporator to within specified tolerances of indicated flow, with all pumps operating. With only one chiller operating in a multiple-chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.

2. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.

3. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.

4. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.

5. Capacity: Calculate in tons of cooling.

6. Efficiency: Calculate operating efficiency for comparison to submitted equipment.

7. Verify condenser-fan rotation and record fan and motor data, including number of fans and entering- and leaving-air temperatures.

3.14. PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Measure and record entering and leaving refrigerant pressures.

D. Measure and record operating data of compressor(s), fan(s), and motors.

3.15. PROCEDURES FOR HYDRONIC BOILERS

A. Measure and record entering- and leaving-water temperatures.

B. Measure and record water flow.

C. Measure and record pressure drop.

D. Measure and record relief valve(s) pressure setting.

E. Capacity: Calculate in Btu/h (kW) of heating output.

F. Fuel Consumption: If boiler fuel supply is equipped with flow meter, measure and record consumption.

G. Efficiency: Calculate operating efficiency for comparison to submitted equipment.

H. Fan, motor, and motor controller operating data.

3.16. PROCEDURES FOR HYDRONIC COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

3.17. PROCEDURES FOR ELECTRIC HEATING COILS

A. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load and at each incremental stage.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

3.18. PROCEDURES FOR REFRIGERANT COILS

A. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.19. PROCEDURES FOR EXHAUST HOODS

A. Room Pressure: Measure and record room pressure with respect to atmosphere and adjacent space with hoods in room initially not operating and then with hoods operating.

B. Makeup Air: Systems supplying source of makeup air to hoods shall be in operation during testing and balancing of exhaust hoods.

1. Measure and record temperature of makeup air entering hood. If hood makeup air is from multiple sources having different temperatures, measure and record the airflow and temperatures of each source and calculate the weighted average temperature.
2. Use simulated smoke to observe supply air-distribution air patterns in vicinity of hoods. Consult with hood manufacturer and report conditions that have a detrimental effect on intended capture, containment, and other attributes effecting proper operation.

C. Rooms with Multiple Hoods: Test each hood separately, one at a time, and repeat tests with all hoods intended to operate simultaneously by design.

D. Canopy Hoods: Measure and record the following:

1. Pressure-drop across hood.

2. Airflow by duct traverse where duct distribution will allow accurate measurement and calculate hood average face velocity.

3. Measure velocity across hood face and calculate hood airflow.

    a. Clearly indicate the direction of flow at each point of measurement.

    b. Measure velocity across opening on not less than 12-inch centers. Record velocity at each measurement and calculate average velocity.

E. Kitchen Hoods:

1. Type 1: Measure and record pressure drop and face velocity of hood filters and slots in accordance with hood manufacturer's instructions. Consult hood manufacturer to determine hood airflow using recorded information.

2. Type 2: Measure and record airflow by duct traverse.

F. AHJ Tests: Conduct additional tests required by authorities having jurisdiction.

3.20. SOUND TESTS

A. After systems are balanced and Owner Acceptance, measure and record sound levels at up to 10 locations designated by the Engineer.

B. Instrumentation:

1. The sound-testing meter shall be a portable, general-purpose testing meter consisting of a microphone, processing unit, and readout.

2. The sound-testing meter shall be capable of showing fluctuations at minimum and maximum levels and measuring the equivalent continuous sound pressure level (Leq).

3. The sound-testing meter must be capable of using one-third octave band filters to measure mid-frequencies from 31.5 Hz to 8000 Hz.

4. The accuracy of the sound-testing meter shall be plus or minus one decibel.

C. Test Procedures:

1. Perform test at quietest background noise period. Note cause of unpreventable sound that affects test outcome.

2. Equipment should be operating at design values.

3. Calibrate the sound-testing meter prior to taking measurements.

4. Use a microphone suitable for the type of noise levels measured that is compatible with meter. Provide a windshield for outside or in-duct measurements.

5. Record a set of background measurements in dBA and sound pressure levels in the eight unweighted octave bands 63 Hz to 8000 Hz (NC) with the equipment off.

6. Take sound readings in dBA and sound pressure levels in the eight unweighted octave bands 63 Hz to 8000 Hz (NC) with the equipment operating.

7. Take readings no closer than 36 inches from a wall or from the operating equipment and approximately 60 inches from the floor, with the meter held or mounted on a tripod.

8. For outdoor measurements, move sound-testing meter slowly and scan area that has the most exposure to noise source being tested. Use A-weighted scale for this type of reading.

D. Reporting:

1. Report shall record the locations, systems tested, dBA readings and sound pressure levels in each octave band with equipment on and off.

2. Plot sound pressure levels on Noise Criteria (NC) worksheet with equipment on and off.

3.21. VIBRATION TESTS

A. After systems are balanced and substantially complete, measure and record vibration levels on the following equipment:

1. Air handling equipment located on elevated floors above occupiable spaces.

B. Instrumentation:

1. Use portable, battery-operated, and microprocessor-controlled vibration meter with or without a built-in printer.

2. The meter shall automatically identify engineering units, filter bandwidth, amplitude, and frequency scale values.

3. The meter shall be able to measure machine vibration displacement in mils of deflection, velocity in inches per second, and acceleration in inches per second squared.

4. Verify calibration date is current for vibration meter before taking readings.

C. Test Procedures:

1. To ensure accurate readings, verify that accelerometer has a clean, flat surface and is mounted properly.

2. With the unit running, set up vibration meter in a safe, secure location. Connect transducer to meter with proper cables. Hold magnetic tip of transducer on top of the bearing, and measure unit in mils of deflection. Record measurement, then move transducer to the side of the bearing and record in mils of deflection. Record an axial reading in mils of deflection by holding nonmagnetic, pointed transducer tip on end of shaft.

3. Change vibration meter to velocity (inches per second) measurements. Repeat and record above measurements.

4. Record CPM or rpm.

5. Read each bearing on motor, fan, and pump as required. Track and record vibration levels from rotating component through casing to base.

D. Reporting:

1. Report shall record location and the system tested.

2. Include horizontal-vertical-axial measurements for tests.

3. Verify that vibration limits follow Specifications, or, if not specified, follow the General Machinery Vibration Severity Chart or Vibration Acceleration General Severity Chart from AABC's "National Standards for Total System Balance." Acceptable levels of vibration are normally "smooth" to "good."

4. Include in General Machinery Vibration Severity Chart, with conditions plotted.

3.22. DUCT LEAKAGE TESTS

A. Witness the duct leakage testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.23. PIPE LEAKAGE TESTS

A. Witness the pipe pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.24. HVAC CONTROLS VERIFICATION

A. In conjunction with system balancing and the BAS Controls Contractor, perform the following:

1. Verify HVAC control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents. Verify each control sequence of operation line-by-line including the operation of all equipment, valves dampers, etc.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.25. TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.

2. Air Outlets and Inlets: Plus 10 percent or minus 5 percent.

3. Heating Water Flow Rate: Plus 10 percent or minus 5 percent.

4. Cooling Water Flow Rate: Plus 10 percent or minus 5 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.26. FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.

2. Include a list of instruments used for procedures, along with proof of calibration.

3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.

2. Fan curves.

3. Manufacturers' test data.

4. Field test reports prepared by system and equipment installers.

5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.

2. Name and address of the TAB specialist.

3. Project name.

4. Project location.

5. Architect's name and address.

6. Engineer's name and address.

7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents, including indicated versus final performance; notable characteristics of systems; and description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans performance forms, including the following:
    a. Settings for outdoor, return, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Heating coil, dry-bulb conditions.
    e. Face and bypass damper settings at coils.
    f. Fan drive settings, including settings and percentage of maximum pitch diameter.
    g. Variable speed controller settings.
    h. Settings for pressure controller(s).
    i. Other system operating conditions that affect performance.
16. Test conditions for pump performance forms, including the following:
    a. Variable-frequency controller settings for variable-flow hydronic systems.
    b. Settings for pressure controller(s).
    c. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.

2. Water flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units, include the following:

1. Unit Data:
    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.
    h. Sheave make, size in inches, and bore.
    i. Center-to-center dimensions of sheave and amount of adjustments in inches.
    j. Number, make, and size of belts.
    k. Number, type, and size of filters.
2. Motor Data:
    a. Motor make, and frame type and size.
    b. Horsepower and speed.
    c. Volts, phase, and hertz.
    d. Full-load amperage and service factor.
    e. Sheave make, size in inches, and bore.
    f. Center-to-center dimensions of sheave and amount of adjustments in inches.
3. Test Data (Indicated and Actual Values):
    a. Total airflow rate in cfm.
    b. Total system static pressure in inches wg.
    c. Fan speed.
    d. Inlet and discharge static pressure in inches wg.

e. Profile of internal pressure losses across each internal component, for example: fan, cooling coil, heating coil, filters, dampers, etc.

1) Exception: Profiles are not required for air handling equipment with capacities of 5,000 cfm and smaller.

f. For each filter bank, filter static-pressure differential in inches wg.

g. Preheat-coil static-pressure differential in inches wg.

h. Cooling-coil static-pressure differential in inches wg.

i. Heating-coil static-pressure differential in inches wg.

j. List for each internal component with pressure-drop, static-pressure differential in inches wg.

k. Outdoor airflow in cfm.

l. Return airflow in cfm.

m. Outdoor-air damper position.

n. Return-air damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.

b. Location.

c. Coil type.

d. Number of rows.

e. Fin spacing in fins per inch o.c.

f. Make and model number.

g. Face area in sq. ft.

h. Tube size in NPS.

i. Tube and fin materials.

j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.

b. Average face velocity in fpm.

c. Air pressure drop in inches wg.

d. Outdoor-air, wet- and dry-bulb temperatures in deg F.

e. Return-air, wet- and dry-bulb temperatures in deg F.

f. Entering-air, wet- and dry-bulb temperatures in deg F.

g. Leaving-air, wet- and dry-bulb temperatures in deg F.

h. Water flow rate in gpm.

i. Water pressure differential in feet of head or psig.

j. Entering-water temperature in deg F.

k. Leaving-water temperature in deg F.

l. Refrigerant expansion valve and refrigerant types.

m. Refrigerant suction pressure in psig.

n. Refrigerant suction temperature in deg F.

G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

a. System identification.

b. Location.

c. Make and type.

d. Model number and unit size.

e. Manufacturer's serial number.

f. Fuel type in input data.

g. Output capacity in Btu/h (kW).

h. Ignition type.

i. Burner-control types.

j. Motor horsepower and speed.

k. Motor volts, phase, and hertz.

l. Motor full-load amperage and service factor.

m. Sheave make, size in inches, and bore.

n. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.

b. Entering-air temperature in deg F.

c. Leaving-air temperature in deg F.

d. Air temperature differential in deg F.

e. Entering-air static pressure in inches wg.

f. Leaving-air static pressure in inches wg.

g. Air static-pressure differential in inches wg.

h. Low-fire fuel input in Btu/h.

i. High-fire fuel input in Btu/h.

j. Manifold pressure in psig.

k. High-temperature-limit setting in deg F.

l. Operating set point in Btu/h.

m. Motor voltage at each connection.

n. Motor amperage for each phase.

o. Heating value of fuel in Btu/h.

H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

a. System identification.

b. Location.

c. Coil identification.

d. Capacity in Btu/h.

e. Number of stages.

f. Connected volts, phase, and hertz.

g. Rated amperage.

h. Airflow rate in cfm.

i. Face area in sq. ft.

j. Minimum face velocity in fpm.

2. Test Data (Indicated and Actual Values):

a. Heat output in Btu/h.

b. Airflow rate in cfm.

c. Air velocity in fpm.

d. Entering-air temperature in deg F.

e. Leaving-air temperature in deg F.

f. Voltage at each connection.

g. Amperage for each phase.

I. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.

b. Location.

c. Make and type.

d. Model number and size.

e. Manufacturer's serial number.

f. Arrangement and class.

g. Sheave make, size in inches, and bore.

h. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Motor Data:

a. Motor make, and frame type and size.

b. Horsepower and speed.

c. Volts, phase, and hertz.

d. Full-load amperage and service factor.

e. Sheave make, size in inches, and bore.

f. Center-to-center dimensions of sheave and amount of adjustments in inches.

g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.

b. Total system static pressure in inches wg.

c. Fan speed.

d. Discharge static pressure in inches wg.

e. Suction static pressure in inches wg.

J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System fan and air-handling-unit number.

b. Location and zone.

c. Traverse air temperature in deg F.

d. Duct static pressure in inches wg.

e. Duct size in inches.

f. Duct area in sq. ft.

g. Indicated airflow rate in cfm.

h. Indicated velocity in fpm.

i. Actual airflow rate in cfm.

j. Actual average velocity in fpm.

k. Barometric pressure in psig.

K. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.

b. Location and zone.

c. Apparatus used for test.

d. Area served.

e. Make.

f. Number from system diagram.

g. Type and model number.

h. Size.

i. Effective area in sq. ft.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.

b. Air velocity in fpm.

c. Preliminary airflow rate as needed in cfm.

d. Preliminary velocity as needed in fpm.

e. Final airflow rate in cfm.

f. Final velocity in fpm.

g. Space temperature in deg F.

L. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.

b. Location and zone.

c. Room or riser served.

d. Coil make and size.

e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.

b. Entering-water temperature in deg F.

c. Leaving-water temperature in deg F.

d. Water pressure drop in feet of head or psig.

e. Entering-air temperature in deg F.

f. Leaving-air temperature in deg F.

M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves, and 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.

g. Water pressure differential in feet of head or psig.

h. Required net positive suction head in feet of head or psig.

i. Pump speed.

j. Impeller diameter in inches.

k. Motor make and frame size.

l. Motor horsepower and rpm.

m. Voltage at each connection.

n. Amperage for each phase.

o. Full-load amperage and service factor.

p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.

b. Pump shutoff pressure in feet of head or psig.

c. Actual impeller size in inches.

d. Full-open flow rate in gpm.

e. Full-open pressure in feet of head or psig.

f. Final discharge pressure in feet of head or psig.

g. Final suction pressure in feet of head or psig.

h. Final total pressure in feet of head or psig.

i. Final water flow rate in gpm.

j. Voltage at each connection.

k. Amperage for each phase.

N. Fume Hood Reports: Test fume hoods as described above.

1. Report data:

a. Sash position.

b. Face velocity (fpm).

c. Air flow (cfm).

d. Pressure drop (inches wg).

O. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.

b. Serial number.

c. Application.

d. Dates of use.

e. Dates of calibration.

3.27. INSPECTIONS

A. Initial Inspection:

1. After testing and balancing is complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.

2. Perform the inspection in the presence of the owner's commissioning agent.

3. Check the following for each system:

a. Measure airflow of at least 10 percent of air outlets.

b. Measure water flow of at least 10 percent of terminals.

c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.

d. Verify that balancing devices are marked with final balance position.

e. Note deviations from the contract documents in the final report.

B. Final Inspection:

1. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of the engineer.

2. Engineer shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

3. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

4. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.

2. If the second final inspection also fails, owner may contract the services of another TAB contractor to complete TAB work according to the contract documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

3.28. 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 230593

SECTION 230713 – DUCT AND DUCTED EQUIPMENT INSULATION

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes insulation of indoor and outdoor supply, return, exhaust, relief and ventilation duct systems.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

1.3. QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Indoors: Flame-spread index of 25 or less and smoke-developed index of 50 or less.

2. Outdoors: Flame-spread index of 75 or less and smoke-developed index of 150 or less.

1.4. DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

B. Storage: Insulation material shall be stored in a dry location sealed in plastic to prevent moisture infiltration. Insulation material, installed or not, that becomes wet, dirty, etc. shall be removed and replaced. “Dried” or “cleaned” insulation materials shall not be used.

1.5. COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields.

B. Coordinate clearance requirements with duct installer for duct insulation application. Before preparing ductwork shop drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.6. SCHEDULING

A. Schedule insulation installation after pressure testing duct systems. Application may begin on segments that have satisfactory test results. Insulation applied prior to satisfactory test results shall be removed and replaced.

PART 2 - PRODUCTS

2.1. INSULATION MATERIALS

A. General: Comply with requirements in Indoor Duct Insulation and Field-Applied Jacket Schedule and Outdoor Duct Insulation and Field-Applied Jacket Schedule articles for where insulating materials shall be applied.

1. Products shall not contain asbestos, lead, mercury, or mercury compounds.

2. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

3. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

4. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

B. Mineral-Fiber Blanket Insulation: Mineral wool or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290. Provide Type II with factory-applied vinyl jacket; Type III with factory-applied FSK jacket; or Type III with factory-applied FSP jacket.

1. R-value requirements defined in Part 3 of this section as based on installed ratings with 25 percent compression.

C. Mineral-Fiber Board Insulation: Mineral wool or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied jacket.

D. Polyisocyanurate Board Insulation: Closed-cell polyisocyanurate rigid foam boards with aluminum foil facing, ASTM C 1289, Type 1, Grade 1 (-100 to +250F). For outdoor use only.

E. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

2.2. FACTORY-APPLIED JACKETS

A. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White outward facing, bleached kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing.

2. FSK Jacket: Aluminum-foil outward facing, fiberglass-reinforced scrim with brown kraft-paper backing.

2.3. FIELD-APPLIED JACKETS

A. Insulation system schedules indicate field-applied jackets for various applications. When field-applied jackets are indicated, comply with the following:

1. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. Moisture Barrier:

1) Indoor Applications: 3-mil thick, heat-bonded polyethylene and kraft paper.

2) Outdoor Applications: 2.5-mil thick polysurlyn.

2. Woven Glass-Fiber Fabric Jacket: Comply with MIL-C-20079H, Type I, plain weave, and pre-sized a minimum of 8 oz./sq. yd.

2.4. DUCT INSULATION INSTALLATION MATERIALS

A. General: Adhesives, mastics and sealants shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated. Indoor applications shall comply with low-VOC requirements of Section 230100.

B. Adhesives:

1. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

2. ASJ Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

3. FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

C. Mastics: Comply with MIL-PRF-19565C, Type II.

1. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

D. Sealants:

1. ASJ Flashing Sealants and Vinyl Flashing Sealants.

2. FSK and Metal Jacket Flashing Sealants.

E. Tapes:

1. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

2. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

3. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

F. Securements:

1. Insulation Pins and Hangers:

a. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch diameter shank, length to suit depth of insulation indicated.

b. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding 0.135-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

c. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

d. Non-Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

e. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

f. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick, stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

g. Non-Metal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

2. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

3. Wire: 0.062-inch soft-annealed, stainless steel.

G. Corner Angles:

1. Aluminum Corner Angles: 0.040-inch thick, minimum 1 by 1-inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

2. Stainless-Steel Corner Angles: 0.024-inch thick, minimum 1 by 1-inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304.

PART 3 - EXECUTION

3.1. INDOOR DUCT INSULATION AND FIELD-APPLIED JACKET SCHEDULE

A. General

1. Unconditioned spaces include attics, crawl spaces, and unheated mechanical rooms. They do not include vertical shafts surrounded by conditioned spaces.

2. Install field-applied jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. General Duct Systems

1. Concealed single-wall duct in conditioned spaces:

    a. Supply and Ventilation Air: 2-inches (R-6) of mineral fiber blanket, field-applied jacket is not required. Mineral fiber blanket shall be paintable ASJ-type on ductwork located above floating ceilings with limited visibility.

    b. Return and Relief Air: None.

    c. General Building Exhaust Air: None.

2. Concealed single-wall duct in unconditioned spaces:

    a. Supply and Ventilation Air: 2-inches (R-6) of mineral fiber blanket, field-applied jacket is not required.

    b. Return and Relief Air: 2-inches (R-6) of mineral fiber blanket, field-applied jacket is not required.

    c. General Building Exhaust Air: None.

3. Exposed-to-view single-wall duct in mechanical equipment spaces:

    a. Supply and Ventilation Air: 2-inches (R-6) of mineral fiber board for rectangular duct and mineral fiber blanket for round and flat oval with field applied woven glass fiber jacket.

    b. Return and Relief Air: None.

    c. General Building Exhaust Air: None.

4. Exposed-to-view single-wall duct in conditioned spaces:

    a. Supply and Ventilation Air: 2-inches (R-6) of mineral fiber board for rectangular duct and mineral fiber blanket for round and flat oval with field applied woven glass fiber jacket.

    b. Return and Relief Air: None.

    c. General Building Exhaust Air: None.

5. Exposed-to-view single-wall duct in unconditioned spaces:

    a. Supply and Ventilation Air: 2-inches (R-6) of mineral fiber blanket with field applied woven glass fiber jacket.

    b. Return and Relief Air: 2-inches (R-6) of mineral fiber blanket with field applied woven glass fiber jacket.

    c. General Building Exhaust Air: None.

6. Concealed or exposed-to-view double-wall duct interstitial insulation in conditioned spaces:

    a. Supply and Ventilation Air: 2-inches (R-6) of mineral fiber blanket, field-applied jacket is not required.

7. Concealed or exposed-to-view double-wall duct interstitial insulation in unconditioned spaces:

    a. Supply and Ventilation Air: 2-inches (R-6) of mineral fiber blanket, field-applied jacket is not required.

    b. Return and Relief Air: 2-inches (R-6) of mineral fiber blanket, field-applied jacket is not required.

8. Concealed within chase on an exterior wall or within an exterior wall:

    a. Supply and Ventilation Air: 2-inches (R-8) of mineral fiber board, field-applied jacket is not required.

    b. Return and Relief Air: 2-inches (R-8) of mineral fiber board, field-applied jacket is not required.

C. Special Exhaust Duct Systems

1. Concealed single-wall duct:

    a. Kitchen Grease Hood (Type 1) Exhaust Air: Fire-rated blanket with thickness required to maintain 2-hour fire rating. Void this requirement where a pre-fabricated pre-insulated double-wall duct systems with an equivalent interstitial insulation is used.

    b. Clothes Dryer Exhaust Air: None.

2. Exposed-to-view single-wall duct:

    a. Kitchen Grease Hood (Type 1) Exhaust Air: None.

    b. Clothes Dryer Exhaust Air: None.

D. Air Plenums

1. Plenums connected to outdoor louvers or hoods:

a. Ventilation Air: 3-inches (R-8) of mineral fiber board with field applied woven glass fiber jacket.

b. Exhaust/Relief Air: 2-inches (R-6) of mineral fiber board with field applied woven glass fiber jacket.

2. Plenums not connected directly to the outdoors:

a. Supply Air: 2-inches (R-6) of mineral fiber board with field applied woven glass fiber jacket.

b. Ventilation Air: 3-inches (R-8) of mineral fiber board with field applied woven glass fiber jacket.

c. Exhaust/Relief Air: 2-inches (R-6) of mineral fiber board with field applied woven glass fiber jacket.

3. Acoustic Plenums and Duct Silencers: Interior or interstitial duct liner shall have the same or greater thermal resistance as the systems they are attached as indicated above.

3.2. OUTDOOR DUCT INSULATION AND FIELD-APPLIED JACKET SCHEDULE

A. General Requirements:

1. Outdoor Duct: Install jacket with a single Z-shaped locking longitudinal seam on the underside of the raised duct and with Z-shaped locking seam traverse joints. All seams shall be mechanically fastened and watertight sealed with flexible mastic.

B. General Duct Systems

1. Single-wall duct:

a. Supply, Ventilation and Return Air: 2-inches (R-10) of polyisocyanurate with 0.032-inch thick stucco embossed aluminum.

C. Plenums

1. Plenums shall be insulated as follows:

a. Supply, Ventilation and Return Air: 2-inches (R-10) of polyisocyanurate with 0.032-inch thick stucco embossed aluminum.

3.3. GENERAL REQUIREMENTS

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.

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

3.4. PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.5. GENERAL INSTALLATION REQUIREMENTS

A. Insulate all components of duct systems as specified with the exception of the following components:

1. Factory-insulated flexible ducts.
2. Factory-insulated plenums and casings.
3. Flexible connectors.
4. Vibration-control devices.
5. Factory-insulated access panels and doors.

B. Provide rigid board insulation strips at duct supports to avoid compression of duct wrap.

C. For ductwork conveying air below ambient temperature, insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, expansion joints, and the backs of supply diffusers.

D. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

E. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

F. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

G. Install insulation with longitudinal seams at top and bottom of horizontal runs.

H. Install multiple layers of insulation with longitudinal and end seams staggered.

I. Keep insulation materials dry during application and finishing.

J. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

K. Install insulation with least number of joints practical.

L. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

M. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

N. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

4. For below ambient services, apply vapor-barrier mastic over staples.

5. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

6. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

O. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

P. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

Q. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.6. PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.

4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.

4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.

2. Seal penetrations through fire-rated assemblies.

3.7. INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

d. Do not over-compress insulation during installation.

e. Impale insulation over pins and attach speed washers.

f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap un-faced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

    b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

    d. Do not over-compress insulation during installation.

    e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1-inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

    b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.8. FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.

2. Embed glass cloth between two 0.062-inch thick coats of lagging adhesive.

3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.

2. Install lap or joint strips with same material as jacket.

3. Secure jacket to insulation with manufacturer's recommended adhesive.

4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch wide joint strips at end joints.

5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

3.9. FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 230500.

3.10. FINISHES

A. Paint duct insulation with ASJ, glass-cloth, or other paintable jacket material. Color shall be selected by the Owner/Engineer. Refer to Section 230553.

1. Prime with 2 coats of water-based white acrylic primer paint designed for use with associated jacket material.

2. Finish with 2 coats of flat latex paint with fungicidal agent additive to render fabric mildew proof.

3. Do not field paint stainless-steel jackets.

B. Apply paint and primer at the recommended spreading rate and film thickness as recommended by the paint manufacturer.

C. Apply paint and primer within the environmental conditions recommended by the paint manufacturer but not less than 55 deg F; not more than 90 deg F; and not more than 70 percent RH.

END OF SECTION 230713

SECTION 230719 – PIPING AND PIPED EQUIPMENT INSULATION

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes insulation of HVAC piping systems:

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

1.3. QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Indoors installed in air plenums: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2. Indoors not installed in air plenums: Flame-spread index of 25 or less, and smoke-developed index of 450 or less.

3. Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 450 or less.

1.4. DELIVERY, STORAGE AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

B. Storage: Insulation material shall be stored in a dry location sealed in plastic to prevent moisture infiltration. Insulation material, installed or not, that becomes wet, dirty, etc. shall be removed and replaced. “Dried” or “cleaned” insulation materials shall not be used.

1.5. COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields.

B. Coordinate clearance requirements with piping installer for piping insulation application. Before preparing piping shop drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.6. SCHEDULING

A. Schedule insulation installation after pressure testing systems and where required after installing and testing heat tracing. Insulation applied prior to satisfactory test results shall be removed and replaced.

PART 2 - PRODUCTS

2.1. INSULATION MATERIALS

A. General: Comply with requirements in Piping Insulation Schedule and Field-Applied Jacket Schedule articles for where insulating materials shall be applied.

1. Products shall not contain asbestos, lead, mercury, or mercury compounds.

2. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

3. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

4. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

5. Fitting Covers: Field apply insulation to cover valves, elbows, tees, and flanges.

B. Mineral-Fiber, Preformed Pipe Insulation:

1. Type I, 850 deg F Materials: Mineral wool or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Johns Manville Micro-Lok, Owens Corning Fiberglas or Engineer approved equal.

2. Thermal conductivity (k-value) maximum value of 0.34 BTU in /(hr sqft deg F) for fluid temperatures above 350 deg F; 0.32 for fluids 350 deg F and lower; 0.30 for fluids 250 deg F and lower; 0.29 for fluids 200 deg F and lower; 0.27 for fluids 60 deg F and lower; and 0.26 for fluids 40 deg F and lower.

C. Mineral-Fiber, Pipe and Tank Insulation: Mineral wool or glass fibers bonded with a thermosetting resin. Semi-rigid board material with factory-applied ASJ jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density shall be 2.5 lb/cu. ft. or more. Owens Corning Fiberglas Pipe and Tank or Engineer approved equal.

1. Thermal conductivity (k-value) maximum value of 0.34 BTU in /(hr sqft deg F) for fluid temperatures above 350 deg F; 0.32 for fluids 350 deg F and lower; 0.30 for fluids 250 deg F and lower; 0.29 for fluids 200 deg F and lower; 0.27 for fluids 60 deg F and lower; and 0.26 for fluids 40 deg F and lower.

D. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials. Armacell AP Armaflex or Engineer approved equal.

1. Thermal conductivity (k-value) maximum value of 0.27 BTU in /(hr sqft deg F) for fluid temperatures 60 deg F and lower

E. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation with factory-applied ASJ-SSL. Johns Manville Trymer or Engineer approved equal.

1. Thermal conductivity (k-value) maximum value of 0.19 BTU in /(hr sqft deg F) for fluid temperatures 60 deg F and lower and 0.23 for fluids 40 deg F and lower.

2. Provide Type V for insulation in exposed locations below 6 feet above finished floor, exterior locations, and other locations subject to damage. Provide Type IV for insulation in exposed locations above 6 feet above finished floor and concealed locations.

3. Fabricate shapes according to ASTM C 450 and ASTM C 585.

2.2. FACTORY-APPLIED JACKETS

A. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White outward facing, bleached kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing.

2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

2.3. FIELD-APPLIED JACKETS

A. Insulation system schedules indicate field-applied jackets for various applications. When field-applied jackets are indicated, comply with the following:

1. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. Moisture Barrier:

1) Indoor Applications: 1.5-mil thick, heat-bonded polyethylene and kraft paper.

2) Outdoor Applications: 3.0-mil thick polysurlyn.

2. PVC Jacket: High-impact resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C, 20-mils thick.

    a. Adhesive: As recommended by jacket material manufacturer.

    b. Color: Select from manufacturer's available pre-colored options. Do not paint in the field. Color scheme shall comply with Section 230553.

    c. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

        1) Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

3. Woven Glass-Fiber Fabric Jacket: Comply with MIL-C-20079H, Type I, plain weave, and pre-sized a minimum of 8 oz./sq. yd.

2.4. INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

2.5. PIPING INSULATION INSTALLATION MATERIALS

A. General: Adhesives, mastics and sealants shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated. Indoor applications shall comply with low-VOC requirements of Section 230100.

B. Adhesives:

1. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
2. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
3. ASJ Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
4. PVC Jacket Adhesive: Compatible with PVC jacket.
5. Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

C. Mastics: Comply with MIL-PRF-19565C, Type II.

1. Vapor-Barrier Mastic: Water based, white, suitable for indoor use on below-ambient services with water-vapor permeance of 0.015 perm at 50-mil dry film thickness per ASTM E 96, Procedure A; service temperature range of minus 20 to plus 180 deg F; and solids content of 58 percent by volume and 70 percent by weight per ASTM D 1644.
2. Breather Mastic: Water based; white, suitable for indoor and outdoor use on above-ambient services with service temperature range of minus 20 to plus 180 deg F; water-vapor permeance of 1.8 perms at 0.0625-inch dry film thickness per ASTM F 1249; and solids content of 60 percent by volume and 66 percent by weight.

D. Sealants:

1. Joint Sealants: Permanently flexible, white or gray, elastomeric sealant with service temperature range of minus100 to plus 300 deg F.
2. FSK and Metal Jacket Flashing Sealants: Fire and water-resistant, aluminum color, flexible, elastomeric sealant with service temperature range of minus 40 to plus 250 deg F.
3. ASJ Flashing Sealants and Vinyl and PVC Jacket Flashing Sealants: Fire and water-resistant, white, flexible, elastomeric sealant with service temperature range of minus 40 to plus 250 deg F.

E. Tapes:

1. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

2. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

3. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

4. PVC Tape: Vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

F. Securements:

1. Bands:

a. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015-inch thick, 3/4-inch wide with wing seal.

b. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020-inch thick, 3/4-inch wide with wing seal.

2. Staples: Outward-clinching insulation staples, nominal 3/4-inch wide, stainless steel or Monel.

3. Wire: 0.062-inch soft-annealed, stainless steel.

4. Insulation Pins and Hangers:

a. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch diameter shank, length to suit depth of insulation indicated.

b. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding 0.135-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

c. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

d. Non-Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

e. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

f. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick, stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

g. Non-Metal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

5. Corner Angles:

    a. Aluminum Corner Angles: 0.040-inch thick, minimum 1 by 1-inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

    b. Stainless-Steel Corner Angles: 0.024-inch thick, minimum 1 by 1-inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304.

PART 3 - EXECUTION

3.1. PIPING INSULATION SCHEDULE

A. General

1. Unconditioned spaces include attics, crawl spaces, and unheated mechanical rooms. They do not include vertical shafts surrounded by conditioned spaces.

2. Install field-applied jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

3. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

a. Drainage piping located in crawl spaces.

b. Exposed-to-view chrome-plated pipes and fittings unless there is a potential for personnel injury.

B. Condensate and Equipment Drain Water, 60 deg F and lower:

1. Indoor Piping:

a. Polyisocyanurate: 1-inch thick for 3/4 to 6-inches NPS.

b. Elastomeric: 1 1/2-inch thick for 3/4 to 2-inches NPS.

2. Outdoor Piping, Above-Grade:

a. Polyisocyanurate: 1-inch thick for 3/4 to 6-inches NPS.

b. Elastomeric: 2-inch thick for 3/4 to 2-inches NPS.

C. Chilled Water, above 40 deg F:

1. Indoor Piping:

a. Polyisocyanurate: 1 1/2-inches thick for 3/4 to 24-inches NPS.

2. Outdoor Piping, Above-Grade:

a. Polyisocyanurate: 2-inches thick for up to 24-inches NPS.

D. Heating-Hot-Water Supply and Return, 200 deg F and below:

1. Indoor Piping:

a. Mineral-Fiber: 1-1/2-inches thick for 3/4 to 1-1/4-inches NPS; 2-inches thick for 1 1/2 to 10-inches NPS; and 3-inches thick for 12 to 24-inches NPS.

2. Outdoor Piping, Above-Grade:

a. Mineral-Fiber: 2-inches thick for 3/4 to 1-1/4-inches NPS; and 3-inches thick for 1 1/2 to 24-inches NPS.

E. Refrigerant Suction and Hot-Gas Piping:

1. Indoor and Above-Grade Outdoor Piping:

a. Elastomeric: 1 1/2-inches thick for 3/4 to 1-1/2-inches NPS.

3.2. EQUIPMENT INSULATION SCHEDULE

A. Insulate indoor and outdoor equipment that is not factory insulated.

B. Chillers: Insulate cold surfaces on chillers, including, but not limited to, evaporator bundles, condenser bundles, heat-recovery bundles, suction piping, compressor inlets, tube sheets, water boxes, and nozzles with one of the following:

1. Flexible Elastomeric: 1 1/2-inches thick.

C. Cooling Equipment: Insulate cooling equipment such as heat exchangers, air separators, expansion/compression tanks, buffer tanks, etc. with one of the following:

1. Flexible Elastomeric: 1 1/2-inches thick.

D. Chilled Water Pumps: Insulate pumps with one of the following:

1. Flexible Elastomeric: 1 1/2-inches thick.

E. Heating Equipment: Insulate heating equipment such as heat exchangers, air separators, expansion/compression tanks, etc. with one of the following:

1. Mineral-Fiber Board: 2-inches thick and 3-lb/cu. ft. nominal density.

2. Mineral-Fiber Pipe and Tank: 2-inches thick.

F. Heating and Hot Water Pumps: Insulate pumps with the following:

1. Mineral-Fiber Board: 2-inches thick and 3-lb/cu. ft. nominal density.

3.3. FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Indoor Equipment and Piping Jacket:

1. Concealed Piping: None.

2. Exposed Piping in mechanical equipment rooms: Pre-colored, 30-mils thick PVC complying with Section 230553.

3. Exposed Piping in Occupied Spaces: Woven glass-fiber fabric jacket painted to match adjacent surfaces.

C. Outdoor Equipment and Piping Jacket:

1. Above Ground Piping: 0.032-inch thick stucco embossed aluminum.

2. Equipment: 0.032-inch thick stucco embossed aluminum.

3.4. EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.

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

3.5. PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.6. GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.

2. Testing agency labels and stamps.

3. Nameplates and data plates.

4. Manholes.

5. Handholes.

6. Cleanouts.

Q. Piping insulation shall be continuous and not interrupted by hangers and supports. Hangers shall include factory-fabricated galvanized steel insulation shields that comply with MSS-58. Insulation installed that encapsulates any part of the hanger shall be removed and reinstalled.

3.7. PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.

4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.

4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 230500 for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.

2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 230500.

3.8. PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.

2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations necessary to access components. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on

each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.9. PUMP INSULATION INSTALLATION

A. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.

B. Fabricate boxes from aluminum, at least 0.050 inch thick.

C. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.10. EQUIPMENT, TANK AND VESSEL INSULATION INSTALLATION

A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of tank and vessel surfaces.

2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.

3. Protect exposed corners with secured corner angles.

4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

a. Do not weld anchor pins to ASME-labeled pressure vessels.

b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.

c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.

d. Do not over-compress insulation during installation.

e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.

f. Impale insulation over anchor pins and attach speed washers.

g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.

6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch pre-stressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings and stretch pre-stressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.

7. Stagger joints between insulation layers at least 3 inches.

8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.

9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.

10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.

2. Seal longitudinal seams and end joints.

3.11. INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.

4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.

2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.

2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3. Install insulation to flanges as specified for flange insulation application.

4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.12. INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.

2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.

3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.

4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.

4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.

2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.

2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.

3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

4. Install insulation to flanges as specified for flange insulation application.

3.13. INSTALLATION OF POLYISOCYANURATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3- and 9-o'clock positions on the pipe.

2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.

3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.

C. Insulation Installation on Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of polyisocyanurate insulation to valve body.

2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3. Install insulation to flanges as specified for flange insulation application.

3.14. FIELD-APPLIED JACKET INSTALLATION

A. Where cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.

2. Embed glass cloth between two 0.062-inch thick coats of lagging adhesive.

3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.15. FINISHES

A. Paint pipe insulation with cloth, or other paintable jacket material. Color shall be selected by the Owner/Engineer. Refer to Section 230553 – HVAC Systems Identification.

1. Prime with 2 coats of water-based white acrylic primer paint designed for use with associated jacket material.

2. Finish with 2 coats of flat latex paint with fungicidal agent additive to render fabric mildew proof.

3. Do not field paint PVC, stainless-steel or other non-paintable jackets.

B. Apply paint and primer at the recommended spreading rate and film thickness as recommended by the paint manufacturer.

C. Apply paint and primer within the environmental conditions recommended by the paint manufacturer but not less than 55F; not more than 90F; and not more than 70% RH.

D. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

END OF SECTION 230719

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SECTION 232113 – HYDRONIC PIPING

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes pipe and fitting materials and joining methods for above ground hydronic piping.

1.2. SUBMITTALS

A. Delegated Design Submittals:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.

2. Locations of pipe anchors and alignment guides and expansion joints and loops.

3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.

B. Qualification Submittals:

1. Welding certificates.

2. Pipe and fitting manufacturing source list confirming the materials will be products of the United States of America.

C. Product Submittals: For each type of product indicated.

1.3. QUALITY ASSURANCE

A. Installer Qualifications:

1. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

2. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

a. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

b. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

B. <u>All piping and fittings shall be products of the United States of America</u>. All other piping and fittings will be removed from the project at the contractor’s expense.

1. This requirement does not apply to piping that is internal to and factory-fabricated and installed in unitary equipment. The requirement does apply to all field-installed piping and skid-mounted assemblies with factory-fabricated and installed piping.

PART 2 - PRODUCTS

2.1. PERFORMANCE REQUIREMENTS

A. Hydronic piping and components shall be capable of withstanding the following working pressures and temperatures. Piping systems shall be pressure tested, leak tested and flushed according to Section 230555 based on these working pressures.

1. Chilled Water Piping: 100 psig at 75 deg F.

2. Heating (140 to 200 deg F) Water Piping: 100 psig at 250 deg F.

3. Make-Up (Domestic) Water Piping: 80 psig at 75 deg F.

2.2. COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Wrought-Copper Fittings and Unions: ASME B16.22.

2.3. STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53 or A 106, black carbon steel with plain ends; ERW electric resistance welded (Type E) or seamless (Type S), Grade B. Refer to Part 3 for applications.

1. "Standard Weight" steel piping is not equal to Schedule 40 at 12-inches NPS and larger. Provide piping materials that comply with Part 3 of this section. The following are the minimum pipe thicknesses for each application:

STEEL PIPE WALL THICKNESSES			
NOMINAL PIPE SIZE (INCHES)	STD. WEIGHT WALL THICKNESS (INCHES)	SCHEDULE 40 WALL THICKNESS (INCHES)	SCHEDULE 80 WALL THICKNESS (INCHES)
3/4	0.113	0.113	0.154
1	0.133	0.133	0.179
1 1/4	0.140	0.140	0.191
1 1/2	0.145	0.145	0.200
2	0.154	0.154	0.218
2 1/2	0.203	0.203	0.276
3	0.216	0.216	0.300
4	0.237	0.237	0.337
6	0.280	0.280	0.432
8	0.322	0.322	0.500
10	0.365	0.365	0.594
12	0.375	0.406	0.688
14	0.375	0.438	0.750
16	0.375	0.500	0.844
18	0.375	0.562	0.938
20	0.375	0.594	1.031
24	0.375	0.688	1.219

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250; raised ground face, and bolt holes spot faced.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of material group 1.1, butt-welded end connections, and raised facings.

H. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4. JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, Grade B7, carbon steel, unless otherwise indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

F. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.5. DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating non-conductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions, 2-inches NPS and smaller: Factory-fabricated ASSE 1079 rated for 150 psig with solder-joint copper alloy and threaded ferrous end connections.

C. Dielectric Flanges, 1 1/2 to 4-inches NPS: Factory-fabricated ASSE 1079 bolted, companion-flange assembly, rated for 150 psig with solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous end connections.

D. Dielectric Nipples, 4-inches NPS and smaller: Factory-fabricated IAPMO PS 66 electro-plated steel nipple complying with ASTM F 1545, inert and non-corrosive propylene, rated for 300 psig, and threaded end connections

PART 3 - EXECUTION

3.1. PIPING APPLICATIONS

A. Heating and Cooling Water Piping, Above Ground, 2-inches NPS and smaller:

1. Copper Piping: Type L, drawn-temper (“hard”) copper tubing, wrought-copper fittings and soldered joints.

2. Steel Piping: Schedule 80, Type S, Grade B steel, Class 125 cast-iron or Class 150 malleable-iron fittings and threaded joints.

B. Heating and Cooling Water Piping, Above Ground, 2 1/2-inches NPS and larger:

1. Steel Piping: Schedule 40, Type E or S, Grade B steel, Class 150 wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and butt-welded and flanged joints.

C. Make-Up (Domestic) Water Piping, Above Ground:

1. Copper Piping: Type L, drawn-temper (“hard”) copper tubing, wrought-copper fittings and soldered joints.

D. Condensate Drain Piping:

1. Copper Piping: Type DWV for 1 1/2-inch and larger piping and Type L for 1 1/4-inch and smaller piping, drawn-temper (“hard”) copper tubing, wrought-copper fittings and soldered joints.

E. Air-Vent Piping: Type K, annealed-temper (“soft”) copper tubing, wrought-copper fittings, and soldered joints.

F. Safety-Valve Inlet and Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.2. PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, line-size full port-ball valve, and short line-size nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

1. Piping 6-inches NPS and smaller: 3/4-inch

2. Piping 8 to 12-inches NPS: 1-inch

3. Piping 14-inches NPS and larger: 2-inch

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow, except drain piping. For drain piping provide a uniform grade of 0.2 percent downward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to Section 232119.

Q. Install unions in piping, 2-inch NPS and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, 2 1/2-inch NPS and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Comply with requirements in Section 230516 for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

U. Comply with requirements in Section 230553 for identifying piping.

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517.

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517.

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230100.

Y. Install pressure / temperature ports as indicated in the details and on the inlet and discharge side of each balancing and control valve.

Z. Utilize wet taps or line stops to connect to existing active piping.

3.3. DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

3.4. HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Comply with requirements in Section 230548 for seismic restraints.

3.5. PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
3. PVC Non-Pressure Piping: Join according to ASTM D 2855.

3.6. MEDIUM TEMPERATURE HEATING WATER PIPING INSTALLATION

A. All MTHW piping 2-inches NPS and smaller shall be socket-welded. Al MTHW piping 2 1/2-inches NPS and larger shall be welded.

3.7. TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519.

3.8. FIELD QUALITY CONTROL

A. Inspect welds in accordance with Section 230100.

B. Flush, leak test and pressure test piping in accordance with Section 230555.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113

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SECTION 232116 – HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes special-duty valves and specialties for hydronic piping systems.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

2. Air-control devices.

3. Hydronic specialties.

B. Close-Out Submittals:

1. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.3. QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide specialty valves, air vents, tanks and strainers by the following, unless otherwise noted:

1. Amtrol

2. Armstrong

3. Bell & Gossett

4. TACO

2.2. PRESSURE REDUCING VALVES

A. Diaphragm-Operated, Pressure-Reducing Valves: Bronze or brass body diaphragm-operated pressure reducing valves with PTFE disc, brass seat, EPT diaphragm, EPDM O-ring stem seals, low inlet pressure check valve, inlet strainer that is removable without system shutdown and non-corrosive valve

seat and stem and ASME labeled. Valve size, capacity and operating pressure shall be selected to suit system. Operating pressure and capacity shall be factory-set and field adjustable.

2.3. SAFETY RELIEF VALVES

A. Diaphragm-Operated Safety Relief Valves: Bronze or brass body diaphragm-operated safety relief valves with PTFE disc, brass seat, EPT diaphragm, EPDM O-ring stem seals, brass and rubber internal wetted working parts, inlet strainer that is removable without system shutdown and non-corrosive valve seat and stem and ASME labeled. Valve size, capacity and operating pressure shall be selected to suit system. Operating relief pressure shall be factory-set with a corresponding relief capacity.

2.4. AIR-CONTROL DEVICES

A. Manual Air Vents: Manual air vent with bronze body, non-ferrous internal parts, screwdriver or thumbscrew operator, 1/2-inch NPS inlet connection and 1/8-inch outlet connection and rated for 150 psig CWP (cold working pressure) and up to 225 deg F operating temperature.

B. Automatic Air Vents: Automatic air vent with bronze body, non-ferrous internal parts, non-corrosive metal float operator, 3/4-inch NPS inlet connection and 1/4-inch outlet connection and rated for 150 psig CWP (cold working pressure) and up to 240 deg F operating temperature.

C. Bladder Expansion Tanks: Factory-fabricated welded steel bladder-type expansion tank with taps for pressure gage, air charge fitting and drain fitting. Tanks shall be rated for 125 psig working pressure and 240 deg F maximum operating temperature and labeled according to ASME Boiler and Pressure Vessel Code Section VIII, Division 1.

1. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.

2. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

D. Tangential-Type Air Separators: Factory-fabricated welded steel tangential-type air separators with perforated stainless steel air collector tube; threaded inlet and outlet connections for 2-inch NPS and smaller and flanged for 2 1/2-inch and larger; and threaded blowdown connection. Separators shall be rated for 125 psig working pressure and 350 deg F maximum operating temperature and ASME labeled. Separators shall be sized for maximum system flow or larger as scheduled. Bell & Gossett Rolairtrol series, Spirotherm Spirovent Air VSR series or TACO ACT series.

1. Strainer: None.

2.5. HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers: Y-pattern strainer with cast-iron body, bolted cover and bottom drain connection; threaded end connections for 2-inch NPS and smaller and flanged for 2 1/2-inch and larger; medium-straining mesh stainless steel strainer screen; and rated for 125 psig CWP (cold working pressure).

B. Stainless-Steel Bellow Flexible Connectors: Flexible connector constructed of stainless steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; capable of 3/8-inch misalignment; threaded end connections for 2-inch NPS and smaller and flanged for 2 1/2-inch and larger; and rated for 150 psig CWP (cold working pressure) and 250 deg F maximum operating temperature. Flexicraft FF/TT series or Engineer approved equal.

2.6. ESCUTCHEONS AND FLOOR PLATES

A. Escutcheons:

1. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

2. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

3. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.

B. Floor Plates:

1. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

2. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1. VALVE APPLICATIONS

A. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

B. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2. HYDRONIC SPECIALTIES INSTALLATION

A. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

B. Install piping from equipment to expansion tank with a 2 percent upward slope toward tank.

C. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

D. When indicated, install expansion tanks on a 4” tall concrete pad on the floor. Vent and purge air from hydronic system and ensure that tank is properly charged with air to suit system Project requirements.

3.3. ESCUTCHEONS AND FLOOR PLATES INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: Install one-piece cast-brass type for new piping installations. Install deep-pattern type where piping sleeve protrudes from the floor or wall.

2. Existing Piping: Install split-casting brass type for existing piping installations.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor-plate type.

2. Existing Piping: Split-casting, floor-plate type.

E. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 232116

SECTION 232119 – HYDRONIC PIPING VALVES

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes general duty valves for HVAC piping systems such as ball, butterfly, check and globe valves and associated accessories.

1.2. SUBMITTALS

A. Product Submittals: For each type of valve indicated.

1.3. QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.

2. ASME B31.1 for power piping valves.

3. ASME B31.9 for building services piping valves.

1.4. DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.

2. Protect threads, flange faces, grooves, and weld ends.

3. Set globe valves closed to prevent rattling.

4. Set ball and plug valves open to minimize exposure of functional surfaces.

5. Set butterfly valves closed or slightly open.

6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.

2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1. GENERAL REQUIREMENTS

A. Manufacturers: Subject to compliance with requirements, provide product by one of the following:

1. Apollo Valves / Conbraco
2. Crane Company / Crane Fluid Systems
3. DeZurik
4. Milwaulkee Valve / Hammond Valve
5. NIBCO
6. Powell Valves

B. Refer to HVAC valve schedule articles for applications of valves.

C. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

D. Valve Sizes: Same as upstream piping unless otherwise indicated.

E. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves 6-inches NPS and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Hand Lever: For quarter-turn valves 4-inches NPS and smaller except plug valves.
4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 plug valves, for each size square plug-valve head.

5. Valves shall be equipped with means to lock them closed in compliance with OSHA Lock-out / Tag-out procedure.

F. Valves in Insulated Piping: Provide valves with 2-inch stem extensions for piping temperatures 180 deg F and lower and 4-inch for above 180 deg F.

1. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.

2. Butterfly Valves: With extended neck.

G. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.

2. Threaded: With threads according to ASME B1.20.1.

3. Socket Welded: 2-inch NPS and smaller piping.

4. Solder Joint: With sockets according to ASME B16.18. Use solder with melting point below 840 deg F, except for ball valves where the melting point shall be below 421 deg F.

H. Valve Bypass and Drain Connections: MSS SP-45.

2.2. BALL VALVES

A. Ball Valves, 2-inches NPS and smaller: Two-piece, full-port, quarter-turn, forged brass ball valves with stainless steel trim, PTFE or TFE seats, adjustable stem packing and anti-blowout stem, rated for 600 psig CWP (cold working pressure). Valves shall comply with MSS SP-110. Valves shall have threaded ends.

2.3. BUTTERFLY VALVES

A. Butterfly Valves, 2 1/2-inches NPS and larger: Iron single-flange, cast-iron or ductile-iron butterfly valves with aluminum bronze disc, stainless steel stem, EPDM seat, rated for 150 psig CWP (cold working pressure). Valve body shall be lug type suitable for bi-directional dead-end service at rated pressure without the use of a downstream flange. Valves shall comply with MSS SP-67, Type I. Valves shall have flanged ends.

2.4. CHECK VALVES

A. Lift Check Valves, 2-inches NPS and smaller: Bronze lift check valves for vertical flow with bronze disc and Class 125 rated for 200 psig CWP (cold working pressure). Valves shall comply with MSS SP-80. Valves shall have threaded ends.

B. Center-Guided Check Valves, 2 1/2-inches NPS and larger: Center-guided spring-loaded globe type check valves with ductile iron body, EPDM or NBR seat, and Class 150 rated for 250 psig CWP (cold working pressure). Valves shall comply with MSS SP-125. Valves shall have flanged ends.

2.5. GLOBE VALVES

A. Globe Valves, 2-inches NPS and smaller: Bronze body with integral seat and union-ring bonnet globe valves with bronze trim, PTFE or TFE seats and asbestos-free packing, Class 150 rated for 300 psig CWP (cold working pressure). Hand-wheels shall be malleable or ductile iron. Valves shall comply with MSS SP-80. Valves shall have threaded ends.

B. Globe Valves, 2 1/2-inches NPS and larger: Iron body and bolted-bonnet globe valves with bronze trim, PTFE or TFE seats and asbestos-free packing, Class 125 rated for 200 psig CWP (cold working pressure). Hand-wheels shall be malleable or ductile iron. Valves shall comply with MSS SP-85. Valves shall have flanged ends.

2.6. MANUAL CALIBRATED BALANCING VALVES

A. Manual Calibrated Balancing Valves:

1. Manufacturers:

a. Armstrong CBV Series

b. Bell & Gossett Circuit Setter Plus Series

c. Griswold QuickSet Series

d. TACO Accu-Flo Series.

e. Victaulic TA 78 Series

2. Flow Verification: Provide a differential pressure versus flow calibration charts for use by the Engineer and TAB sub-contractor.

B. Manual Calibrated Balancing Valves, 2-inches NPS and smaller: Manual balancing valve with bronze or copper-alloy body; calibrated ball or globe type orifice or venturi for flow control; brass or stainless ball; PTFE seat; two pressure gage connections with integral seals for portable differential pressure meter; drain tapping; and rated for 125 psig CWP (cold working pressure). Valve shall have hand lever shall have memory stop and integral pointer and calibrated scale to register the degree of valve opening. Valves shall have threaded ends.

2.7. CONTROL VALVES

A. Comply with the requirements of Section 239010.

PART 3 - EXECUTION

3.1. EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2. VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Install valves in branch lines to isolate sections of the piping system.

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

D. Install valves in horizontal piping with stem at or above center of pipe. Valves with stems below center of piping are not acceptable.

E. Install valves in position to allow full stem movement.

F. Valves shall be equipped with stem extensions for all applications where the piping will be insulated.

G. Install shut-off duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

H. Install check valves at each pump discharge and elsewhere as required to control flow direction.

I. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.

2. Wafer-Type Check Valves: In horizontal or vertical position, between flanges.

3. Lift Check Valves: With stem upright and plumb.

J. Install control valves in locations indicated in details and as needed to perform the sequence of operations.

K. Install pressure / temperature ports as indicated in the details and on the inlet and discharge side of each balancing and control valve.

3.3. ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4. GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. Hydronic piping systems shall use the following valve types unless otherwise indicated on the drawings or in other Division 23 sections:

1. Shutoff: Ball or butterfly.

2. Throttling: Globe, ball or butterfly.

3. Pump Discharge Check Valves: Lift check valves for 2-inches NPS and smaller. Non-slam, center-guided, globe type check valves for 2 1/2-inches NPS and larger.

4. Balancing:

a. Two-Way Modulating, Pressure Independent Control Valves: None.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

END OF SECTION 232119

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SECTION 232123 – HYDRONIC PUMPS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes HVAC hydronic system pumps.

1.2. SUBMITTALS

A. Product Submittals: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

1. Proposed pump data shall include all potential motor sizes, impeller sizes, total head, flow rates and efficiency curves. Pump curves showing only the proposed selection point data is not acceptable.

B. Close-Out Submittals:

1. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.3. QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

B. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

C. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

1.4. EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Centrifugal Pumps:

a. Armstrong Pumps

b. Bell & Gossett

c. Grundfos

d. Patterson

e. TACO

B. Motors: Comply with requirements of Section 230513.

2.2. CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.

B. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage-tappings at inlet and outlet, replaceable bronze wear rings and flanged connections.

2. Impeller: Stainless steel Type 304; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.

3. Pump Shaft: Stainless steel or carbon steel.

4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and ethylene propylene terpolymer (EPT) or ethylene propylene rubber (EPR) bellows and gasket. Include water slinger on shaft between motor and seal.

5. Pump Bearings: Permanently lubricated ball bearings.

C. Motor: Single speed and rigidly mounted to pump casing.

2.3. SEPARATELY COUPLED, VERTICALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically.

B. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, replaceable bronze wear rings and flanged connections.

2. Impeller: Stainless steel Type 304; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps not frequency-drive controlled, trim impeller to match specified performance.

3. Pump Shaft: Stainless steel or carbon steel.

4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and ethylene propylene terpolymer (EPT) or ethylene propylene rubber (EPR) bellows and gasket. Include water slinger on shaft between motor and seal.

5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.

6. Pump Bearings: Permanently lubricated ball bearings.

C. Shaft Coupling: Axially split spacer coupling.

D. Motor: Single speed and rigidly mounted to pump casing with lifting eyebolt and supporting lugs in motor enclosure.

2.4. PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

1. Angle pattern.
2. 175-psig pressure rating, ductile-iron body and end cap, pump-inlet fitting.
3. Strainer:
    a. Closed-Loop Systems: Bronze fine-straining startup screen and stainless-steel medium-straining permanent screen strainers.
4. Bronze or stainless-steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.

B. Triple-Duty Valve:

1. Angle or straight pattern.
2. 175-psig pressure rating, ductile-iron body, pump-discharge fitting.
3. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
4. Brass gage ports with integral check valve and orifice for flow measurement.

PART 3 - EXECUTION

3.1. EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations for suitable conditions where pumps are to be installed.

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

3.2. PUMP INSTALLATION

A. Comply with HI 1.4 and HI 2.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Equipment Mounting:

1. Where indicated on the drawings, install in-line pumps on cast-in-place concrete equipment bases.

2. Where in-line installation is indicated on the drawings, install in-line pumps with continuous-thread hanger rods and spring hangers with vertical-limit stop of size required to support weight of in-line pumps.

3.3. CONNECTIONS

A. Where installing piping adjacent to pump, allow space for service and maintenance.

B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

D. Install triple duty and shutoff valve on discharge side of pumps not equipped with a variable speed drive. Install check and shutoff valves on discharge side of pumps equipped with a variable speed drive.

E. Install shutoff valve, Y-pattern strainer, and suction diffuser on suction side of pad-mounted vertical in-line pumps and install shutoff valve and Y-pattern strainer on suction side of in-line pumps.

F. Install flexible connectors on suction and discharge sides of pad-mounted pumps between pump casing and valves.

G. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping or install single gage with multiple-input selector valve. A single differential pressure gauge is not acceptable.

H. Ground equipment according to Division 26 specifications.

I. Connect wiring according to Division 26 specifications.

3.4. STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Check piping connections for tightness.

3. Clean strainers on suction piping.

4. Perform the following startup checks for each pump before starting:

a. Verify bearing lubrication.

b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.

c. Verify that pump is rotating in the correct direction.

5. Prime pump by opening suction valves and closing drains and prepare pump for operation.

6. Start motor.

7. Open discharge valve slowly.

3.5. DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 232123

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SECTION 232133 – UNDERGROUND HYDRONIC PIPING

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes pipe and fitting materials and joining methods for underground hydronic piping.

1.2. SUBMITTALS

A. Delegated Design Submittals:

1. Show pipe sizes, locations, and elevations. Show piping in trench with details showing clearances between piping, and show insulation thickness.

2. Provide additional piping materials to accommodate adjustment for field conditions, piping and fittings not used shall be turned over to the Owner:

B. Qualification Submittals:

1. Installation certification from the piping system manufacturer.

C. Product Submittals: For each type of product indicated.

1.3. QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

B. All buried piping systems shall be able to withstand H-20 highway loading with 3 feet of compacted backfill cover.

C. Manufacturer’s factory authorized personnel or field installation inspector shall conduct regular inspections of the piping as work progresses. At a minimum, the vendor shall include in the price the cost for three (3) site visits with a minimum time on site of three (3) hours each visit in order to conduct the regular inspections of the piping as work progresses. The inspector shall be on site as required to inspect all field joints, installations, and test to ensure the piping system is installed per the manufacturer’s recommendations. Provide inspection reports and corrective action item reports to the Owner, GC, and Engineer within 24 hours of the inspection.

1.4. WARRANTY

A. Manufacturer’s warranty of piping and fitting defects for 10-years from the date of Owner Acceptance. The warranty shall include the cost to remove and replace the defective piping and fittings and related damage caused by the failure.

PART 2 - PRODUCTS

2.1. PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be pressure tested, leak tested and flushed according to Section 230555 based on the following operating pressures:

1. Cooling Water Closed Loop Systems: 100 psig.

2.2. POLYPROPYLENE PIPING

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Aquatherm (Blue Pipe / Faser)

2. Niron (Clima PP-RCT)

3. Uponor (PP-RCT Series Pipe)

B. Description: Polypropylene Random Copolymer (PP-R) and Polypropylene Random Copolymer Chrystalline Temperature (PP-RCT) pipe tubing and fitting materials shall be manufactured from a PP-R resin meeting the short-term properties and longterm strength requirements and rated pressure requirements of ASTM F 2389 or CSA B137.11 and complying with NSF 14 and NSF 61. The pipe shall contain no rework or recycled materials except that generated in the manufacturer's own plant from resin of the same specification from the same raw material. All pipe shall be made in an extrusion process. Hydronic hot water and heating piping shall contain a fiber layer (faser) to restrict thermal expansion. All pipe shall be certified by NSF International as complying with NSF 14, and ASTM F 2389 or CSA B137.11. PP-R piping shall be temperature rated for 0°F to 200°F, SDR 11 to SDR 7.4 for sizes 1 inch and larger. SDR 9 shall have a minimum permissible working pressure of 100 psig at 200°F.

1. Underground Piping: Polypropylene (PP-R) piping in SDR 7.4, 9, or 11 wall ratio per manufacturer’s instructions and ASTM D2774.

2. Fittings shall be manufactured from a PP-R resin meeting the short-term properties and long-term strength requirements of ASTM F 2389. The fittings shall contain no rework or recycled materials except that generated in the manufacturer's own plant from resin of the same specification from the same raw material. All fittings shall be certified by NSF International as complying with NSF 14, and ASTM F 2389 or CSA B137.11.

3. UV Protection: Factory-applied ultraviolet-resistant coating for direct ultraviolet light exposure. UV protection shall be provided for underground and above ground piping.

4. Temperature and Pressure Ratings: Material temperature and pressure ratings shall exceed 125 percent of the design criteria.

PART 3 - EXECUTION

3.1. EARTHWORK

A. Comply with Section 230300 and Division 31 for excavating, trenching, and backfilling.

3.2. PIPING APPLICATION

A. Chilled Water Piping, Direct Buried: Polypropylene Random (PP-R) and Polypropylene Random Copolymer Chrystalline Temperature (PP-RCT) piping.

3.3. PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Remove standing water in the bottom of trench.

C. Do not backfill piping trench until field quality-control testing has been completed and results approved.

D. Install piping at uniform grade of 0.2 percent. Install drains, consisting of a tee fitting, 3/4-inch NPS ball valve, and short 3/4-inch NPS threaded nipple with cap, at low points and elsewhere as required for system drainage. Install manual air vents at high points.

E. In conduits, install drain valves at low points and manual air vents at high points.

F. Install components with pressure rating equal to or greater than system operating pressure.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. See Section 230517 for sleeves and mechanical sleeve seals through exterior building walls.

J. Secure anchors with concrete thrust blocks.

3.4. JOINT CONSTRUCTION

A. Plastic Piping Heat Fusion Joints: Clean and dry joining surfaces. Join pipe and fittings according to the manufacturer’s installation guidelines.

3.5. IDENTIFICATION

A. Install continuous plastic underground warning tapes during back filling of trenches for underground hydronic piping. Locate tapes 6 to 8 inches below finished grade, directly over piping. Comply with the requirements of Section 230300 for warning-tape materials and devices and their installation.

3.6. FIELD QUALITY CONTROL

A. Inspect welds in accordance with Section 230100.

B. Flush, leak test and pressure test piping in accordance with Section 230555.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

END OF SECTION 232133

SECTION 232300 – REFRIGERANT PIPING

PART 1 - GENERAL

1.1. SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

B. Close-Out Submittals:

1. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.3. PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig.

2. Suction Lines for Heat-Pump Applications: 535 psig.

3. Hot-Gas and Liquid Lines: 535 psig.

1.4. QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.5. DELIVERY, STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

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PART 2 - PRODUCTS

2.1. COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type K or L hard drawn.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8.

F. Flexible Connectors: Tin-bronze bellows body with woven, flexible, tinned-bronze-wire-reinforced protective jacket, socket end connections, factory-tested to 500 psig, and rated for 250 deg F maximum operating temperature. Connector shall be capable of minimum 3/4-inch misalignment in minimum 7-inch long assembly.

2.2. REFRIGERANTS

A. Equipment shall utilize the refrigerant type indicated.

1. R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1. PIPING APPLICATIONS

A. Air-Conditioning Suction, Liquid and Hot-Gas Lines, 4-inch NPS and Smaller: Type L, drawn-temper ("hard") copper tubing and wrought-copper fittings with soldered joints.

B. Heat Pump Suction, Liquid and Hot-Gas Lines, 4-inch NPS and Smaller: Type L, drawn-temper ("hard") copper tubing and wrought-copper fittings with soldered joints.

3.2. PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Section 230900 for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:

1. Install horizontal suction lines with a uniform slope downward to compressor.

2. Install traps and double risers to entrain oil in vertical runs.

3. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

R. Identify refrigerant piping and valves according to Section 230553.

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517.

T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517.

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230100.

3.3. PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

3.4. HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Section 230529.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.

2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.

3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.

4. Spring hangers to support vertical runs.

5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing per Section 230529.

D. Support multi-floor vertical runs at least at each floor.

3.5. FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.

2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.

3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.

a. Fill system with nitrogen to the required test pressure.

b. System shall maintain test pressure at the manifold gage throughout duration of test.

c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.

d. Remake leaking joints using new materials and retest until satisfactory results are achieved.

3.6. SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.

2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.

3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.

4. Charge system with a new filter-dryer core in charging line.

3.7. ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.

2. Verify that compressor oil level is correct.

3. Open compressor suction and discharge valves.

4. Open refrigerant valves except bypass valves that are used for other purposes.

5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

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SECTION 232500 – HVAC WATER TREATMENT

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes components of closed-circuit hydronic water treatment systems.

1.2. SUBMITTALS

A. Qualification Submittals:

1. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

B. Product Submittals: For each type of product indicated include rated capacities, operating characteristics, and furnished specialties and accessories.

1. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems.

2. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.

C. Close-Out Submittals:

1. Operation and Maintenance Data: Include emergency, operation, and maintenance manuals for each system component.

1.3. QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

B. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

C. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

1.4. WATER TREATMENT PROVIDER

A. Water treatment service and chemicals shall be performed by the Contractor with an Owner approved vendor.

PART 2 - PRODUCTS

2.1. PERFORMANCE REQUIREMENTS

A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or to the environment.

B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed-Circuit Hydronic System Water Qualities: Maintain the following range of values:

1. pH: 9.0 to 10.5.
2. "P" Alkalinity: 100 to 500 ppm.
3. Boron: 100 to 200 ppm.
4. Chemical Oxygen Demand: 100 ppm maximum (not applicable to glycol solutions).
5. Soluble Copper: 0.20 ppm maximum.
6. Total Suspended Solids (TSS): 10 ppm maximum.
7. Ammonia: 20 ppm maximum.
8. Free Caustic Alkalinity: 20 ppm maximum.

9. Microbiological Limits:

    a. Total Aerobic Plate Count: 1,000 organisms/mL maximum.

    b. Total Anaerobic Plate Count: 100 organisms/mL maximum.

    c. Nitrate Reducers: 100 organisms/mL maximum.

    d. Sulfate Reducers: 0 organisms/mL maximum.

    e. Iron Bacteria: 0 organisms/mL maximum.

2.2. MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: 5-gallon steel bypass feeder rated for 125 psig minimum working pressure with corrosion-resistant exterior coating; minimum 3 1/2-inch fill opening in the top; and 3/4-inch NPS bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel. Manufactured by Amtrol, Armstrong, Bell & Gossett or TACO.

2.3. CHEMICAL TREATMENT TEST EQUIPMENT

A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for testing pH, TSS, inhibitor, chloride, alkalinity, and hardness; sulfite and testable polymer tests for high-pressure boilers.

B. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.

1. Two station rack for closed-circuit systems.

2.4. CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified.

PART 3 - EXECUTION

3.1. WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2. INSTALLATION

A. Install chemical application equipment on concrete bases level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install water-testing equipment on wall near water-chemical-application equipment.

C. Bypass Feeders: Install in closed hydronic systems.

1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.

2. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.

3. Install ball isolation valves on inlet, outlet, and drain below feeder inlet.

4. Install a swing check on inlet after the isolation valve.

3.3. CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings.

D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet.

E. See Section 221319 for backflow preventers required in makeup-water connections to potable-water systems.

3.4. FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.

2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.

3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC system's startup procedures.

4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.

5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.

7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.

8. Repair leaks and defects with new materials and retest piping until no leaks exist.

C. Equipment will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. At four-week intervals following Owner Acceptance, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to "Performance Requirements" Article.

F. Comply with ASTM D 3370 and with the following standards:

1. Silica: ASTM D 859.

2. Acidity and Alkalinity: ASTM D 1067.

3. Iron: ASTM D 1068.

4. Water Hardness: ASTM D 1126.

3.5. MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion, scale formation, and biological growth for all hydronic systems and equipment. Services and chemicals shall be provided for a period of one year from date of Owner Acceptance and shall include the following:

1. Initial water analysis and HVAC water-treatment recommendations.
2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
3. Periodic field service and consultation.
4. Customer report charts and log sheets.
5. Laboratory technical analysis.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.6. DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION 232500

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SECTION 233113 – METAL DUCTS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes single and double-wall round, oval and rectangular metal duct and fittings and associated sealants, gaskets, hangers and supports.

1.2. PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE-62.1.

1.3. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1. Shop Drawings: For all new ductwork and accessories.

a. Factory and shop-fabricated ducts and fittings.

b. Reinforcement and spacing.

c. Seam and joint construction.

d. Details for penetrations through fire-rated and other partitions.

e. Hangers and supports, including methods for duct and building attachment and vibration isolation.

f. Sheet metal thicknesses.

2. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

a. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.

b. Suspended ceiling components.

c. Structural members to which duct will be attached.

d. Size and location of initial access modules for acoustical tile.

e. Penetrations of smoke barriers and fire-rated construction.

f. Items penetrating finished ceiling

B. Construction Submittals:

1. Leakage Test Report: Documentation of work performed for compliance with ASHRAE 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."

C. Close-Out Submittals:

1. As-Built Documents: Provide revised coordination drawings to match the installed conditions.

1.4. DEFINITIONS

A. System Operating Pressure: Duct system operating pressure is equal to the scheduled external static pressure, unless otherwise noted.

1. Duct downstream of air terminal units, between terminal unit discharge and diffuser inlet, the operating pressure may be reduced to 1-inch w.g., unless otherwise noted.

PART 2 - PRODUCTS

2.1. SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations and other imperfections.

B. Galvanized Steel Sheets: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation:

a. G60: Non-hazardous systems such as supply, return, ventilation, relief and general building exhaust duct installed indoors.

b. G90: Hazardous exhaust duct and all duct installed outdoors.

2. Finishes for Surfaces Exposed-to-View: Painted.

C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 316 or 304, cold rolled, annealed, sheet. Exposed surface finish shall be No.4.

D. Aluminum Sheets: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36-inches or less; 3/8-inch minimum diameter for lengths longer than 36-inches.

2.2. DUCT CONSTRUCTION

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class with the following exceptions:

1. Minimum Sheet Metal Thickness:

a. Non-hazardous ducted systems including supply, return, ventilation, relief and general building exhaust air.

1) Galvanized Sheet Steel: 0.028-inches (24-gage).

2) Stainless Sheet Steel: 0.025-inches (24-gage).

3) Aluminum Sheet Metal: 0.020-inches (24-gage).

2. Minimum Construction Standards: Refer to the Table below for minimum construction standards in addition to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

METAL DUCT MINIMUM CONSTRUCTION STANDARDS

DUCT SYSTEMS	MAXIMUM OPERATING PRESSURE (+/- IN WG)	SMACNA DUCT PRESSURE CLASS. (+/- IN WG)	SMACNA SEAL CLASS (A, B or C)	SMACNA LEAKAGE CLASS (CL)	LONGITUDINAL SEAM TYPES	TRANSVERSE JOINT TYPES	FITTING CONSTRUCTION
RECTANGULAR DUCT	1.0	1	B	8	L-1	T-1, 3, 6, 17, 19, 22, 24 (Note #3)	6, 7 and 8
	1.5	2	B	8	L-1	T-1, 3, 6, 17, 19, 22, 24 (Note #3)	6 and 7
	2.5	3	A	8	L-1	T-17, 19, 22 and 24 (Note #3)	6 and 7
	3.0	4	A	4	L-1	T-22 (Note #3)	6 and 7
	5.0	6	A	4	L-1	T-22 (Note #3)	6 and 7
	8.0	10	A	4	L-1	T-22 (Note #3)	6 and 7
ROUND DUCT WITH LONGITUDINAL SEAMS	1.0	1	B	8	RL-4, 5, 6A, 6B, 7 and 8	RT-1, 2, 3, 4, 5 and 6 (Note #4)	10 and 14
	1.5	2	B	8	RL-4 and 5	RT-1 and 2 (Note #4)	10, 11, 13 and 14
	2.5	3	A	4	RL-4 and 5	RT-2 (Note #4)	10, 11, 13 and 14
	3.0	4	A	2	RL-4 and 5 (Poss. Press. Only)	RT-2 (Note #4)	10, 11, 13 and 14
	5.0	6	A	2	RL-4 and 5 (Poss. Press. Only)	RT-2 (Note #4)	10, 11, 13 and 14
	8.0	10	A	2	RL-4 and 5 (Poss. Press. Only)	RT-2 (Note #4)	10, 11, 13 and 14
ROUND DUCT WITH SPIRAL SEAMS	1.0	1	B	8	RL-1 (Spiral)	RT-1 and 2 (Note #4)	10, 11, 13 and 14
	1.5	2	B	8	RL-1 (Spiral)	RT-2 (Note #4)	10, 11, 13 and 14
	2.5	3	A	4	RL-1 (Spiral)	RT-2 (Note #4)	10, 11, 13 and 14
	3.0	4	A	2	RL-1 (Spiral)	RT-2 (Note #4)	10, 11, 13 and 14
	5.0	6	A	2	RL-1 (Spiral)	RT-2 (Note #4)	10, 11, 13 and 14
	8.0	10	A	2	RL-1 (Spiral)	RT-2 (Note #4)	10, 11, 13 and 14
FLAT OVAL DUCT WITH LONGITUDINAL SEAMS	1.0	1	B	8	RL-4 and 5	RT-2 (Note #5)	12, 13 and 14
	1.5	2	B	8	RL-4 and 5	RT-2 (Note #5)	12, 13 and 14
	2.5	3	A	4	RL-4 and 5	RT-2 (Note #5)	12, 13 and 14
	3.0	4	A	2	RL-4 and 5 (Poss. Press. Only)	RT-2 (Note #5)	12, 13 and 14
	5.0	6	A	2	RL-4 and 5 (Poss. Press. Only)	RT-2 (Note #5)	12, 13 and 14
	8.0	10	A	2	RL-4 and 5 (Poss. Press. Only)	RT-2 (Note #5)	12, 13 and 14
FLAT OVAL DUCT WITH SPIRAL SEAMS	1.0	1	B	8	RL-1 (Spiral)	RT-1 and 2 (Note #5)	12, 13 and 14
	1.5	2	B	8	RL-1 (Spiral)	RT-2 (Note #5)	12, 13 and 14
	2.5	3	A	4	RL-1 (Spiral)	RT-2 (Note #5)	12, 13 and 14
	3.0	4	A	2	RL-1 (Spiral)	RT-2 (Note #5)	12, 13 and 14
	5.0	6	A	2	RL-1 (Spiral)	RT-2 (Note #5)	12, 13 and 14
	8.0	10	A	2	RL-1 (Spiral)	RT-2 (Note #5)	12, 13 and 14

NOTES:

1. REFER TO SMACNA 'HVAC DUCT CONSTRUCTION STANDARD - METAL AND FLEXIBLE' (2005) FOR SEAM, JOINT AND FITTING TYPES.
2. REFER TO SMACNA 'HVAC AIR DUCT LEAKAGE TEST MANUAL' (2012) FOR PRESSURE, SEAL AND LEAKAGE CLASSES.
3. FACTORY-FABRICATED SLIDE-ON CONNECTORS ALSO MAY BE USED, DUCTMATE TYPE 35 OR 25, OR EQUAL BY WARD OR NEXUS.
4. FACTORY-FABRICATED SLIDE-ON CONNECTORS ALSO MAY BE USED, DUCTMATE SPIRAL-MATE, OR EQUAL BY WARD OR NEXUS.
5. FACTORY-FABRICATED SLIDE-ON CONNECTORS ALSO MAY BE USED, DUCTMATE OVAL-MATE, OR EQUAL BY WARD OR NEXUS.
6. OPERATING PRESSURES ARE BASED ON MAXIMUM DESIGN PRESSURES, ALSO REPRESENTED AS EXTERNAL STATIC PRESSURES (ESP).
7. USE MINIMUM SMACNA DUCT PRESSURE CLASSIFICATION OF 1 IN WG. DO NOT USE 1/2 INCH CLASSIFICATION.

B. Double-Wall Duct:

1. Double-wall rectangular ducts and fittings shall be fabricated in an off-site dedicated ductwork fabrication shop. Field fabricated double-wall duct will not be accepted.

a. Interstitial Insulation: Comply with Section 230713.

b. Minimum Thermal Resistance: Comply with Section 230713.

c. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.

d. Inner Duct: Minimum 24-gage solid galvanized sheet steel.

2. Double-wall round and flat-oval ducts and fittings shall be fabricated in an off-site dedicated ductwork fabrication shop. Field fabricated double-wall duct will not be accepted.

a. Interstitial Insulation: Comply with Section 230713

b. Minimum Thermal Resistance: Comply with Section 230713

c. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.

d. Inner Duct: Minimum 24-gage solid galvanized sheet steel.

C. Intermediate Reinforcement: Match duct material.

D. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE-1 with minimum 1.5 radius-to-diameter ratio.

b. Radius Type RE-3 with minimum 1.0 radius-to-diameter ratio and two vanes.

c. Mitered Type RE-2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

1) Fabricate elbows with single thickness blades with 2-inch inside radius for ducts with dimensions up to 36x36 and double thickness blades for dimensions 36x36 and larger.

2) Turning vanes may be deleted when duct dimensions are less than 12x12.

2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

a. Elbows shall be solid welded gored type constructed in accordance with Fig. 3-6 and Table 3-1 of SMACNA HVAC Duct Construction Standards. Mitered elbows may only be used where indicated on the Drawings. When used, mitered elbows shall always be supplied with single thickness turning vanes.

b. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

1) Velocity up to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.

2) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.

c. Round Elbows:

1) Diameter 8-inches and Smaller: Stamped or pleated.

a) Adjustable elbows with lock-form joints are also acceptable.

2) Diameter 10-inches and Larger: Welded gore-type.

a) 90-degree elbows shall have minimum 5 gores.

b) 45-degree elbows shall have minimum 3 gores.

E. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.

b. Rectangular Main to Round Branch:

1) Velocity up to 1500 fpm: Conical.

2) Velocity greater than 1500 fpm: 45-degree lateral.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

a. Round and Flat Oval Main to Round Branch:

1) Velocity up to 1000 fpm: 90-degree tee.

2) Velocity up to 2000 fpm: Conical.

3) Velocity greater than 2000 fpm: 45-degree lateral.

3. Construct tees, bends, and elbows with minimum radius 1-1/2 times centerline duct width. Where not possible and where rectangular elbows are used, provide airfoil turning vanes. Where acoustical lining is indicated, furnish turning vanes of perforated metal with glass fiber insulation.

4. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.

5. Fabricate continuously welded round and oval duct fittings two gages heavier than duct gages indicated in SMACNA Standard. Minimum 4-inch cemented slip joint, brazed or electric welded. Prime coat welded joints.

6. Provide standard 45-degree lateral wye takeoffs. When space does not allow 45-degree lateral wye takeoff, use 90-degree conical tee connections. Straight 90-degree round take-offs are allowed off rectangular ducts for single diffuser taps only.

7. Divided or diverging flow fittings shall be constructed as separate fittings. Tap collars welded into spiral duct sections are not acceptable.

F. Exhaust Hood Connections: Gasketed flanges compatible with hood usage.

G. General Cleanliness Requirements: Comply with SMACNA’s “Duct Cleanliness for New Construction Guidelines”.

1. Minimum Duct Cleanliness Level: C (“Advanced Level”)

a. Internal surfaces shall be wiped clean after fabrication prior to sealing for shipment.

b. Self-adhesive labels may be affixed to only the outside surfaces of the duct.

2.3. TRAVERSE DUCT CONNECTION SYSTEM

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ductmate.

2. Ward.

3. Nexus.

B. Product Description: SMACNA "F" rated or SMACNA "J" rated rigidity class connection, interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips.

C. Duct connectors shall be equal to Ductmate 35 or 25 Systems, slide-on type. The 35 System joint shall be the equivalent of a SMACNA "J" connection. The 25 System joint shall be the equivalent of the SMACNA "F" connection. Duct connectors shall be tested by an independent recognized testing laboratory.

D. Duct connectors shall consist of roll formed angle frames with integral sealant, corner pieces with nuts and bolts, metal cleats and gasketing. (Metal cleats only, PVC cleats not acceptable, with the exception of breakaway joints at fire damper sleeves.)

E. Gasketing shall be equal to Ductmate Type 440 synthetic polymer (Butyl) based gasket/sealing tape or approved equal.

F. Connectors shall be selected for the system duct construction specified. Select in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible and the manufacturers published criteria for positive and negative applications. The manufacturer shall assist in the selection of all duct connectors. Select methods of construction and gages as required to accommodate prefabricated duct connectors.

G. Angle flange connectors shall be fastened in each corner and 12-inches o/c minimum thereafter unless the MFR requires more stringent fastening. The type/style of fastening must be submitted for approval prior to ductwork fabrication.

2.4. PRE-FABRICATED GREASE DUCTS

A. Description: Zero-clearance double-wall metal vents tested according to UL 1978 and rated for 500 deg F continuously, or 2000 deg F for 30 minutes; with positive or negative duct pressure and complying with NFPA 211.

B. Construction: ASTM A 666, Type 304 stainless steel inner shell and stainless steel outer jacket with No. 4 finish when exposed-to-view, separated by at least 2-inch annular space filled with high-temperature, ceramic-fiber insulation.

C. Accessories: Tees, elbows, increasers, 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. Include unique components required to comply with NFPA 96 including cleanouts, transitions, adapters and drain fittings.

2.5. SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 4 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
   a. Type: S.
   b. Grade: NS.
   c. Class: 25.
   d. Use: O.
2. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

2.6. HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. 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.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.

3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1. DUCT SCHEDULE

A. General Building Air Systems: Applies to general building supply, return, exhaust, ventilation and relief air duct. Refer to Part 2, Metal Duct Minimum Construction Standards chart for construction standards for General Building Air Systems ductwork. Refer to this Part 3 Duct Schedule section for special applications.

1. Indoor Duct:

a. Concealed or Exposed to View in Mechanical Rooms: Single-wall galvanized sheet steel. Round and oval duct shall have longitudinal or spiral seams.

b. Exposed to View in Occupied Spaces: Double-wall galvanized sheet steel. Round and oval duct shall have spiral seams.

2. Special Applications:

a. Shower, Bathing, and Dishwashing Areas: Duct up to 10-feet from each air inlet shall be constructed with Type 304 stainless steel or aluminum.

B. Air Plenums: Applies to air plenums for general building ventilation and relief air systems.

1. Construction: Plenums shall be constructed with materials matching connected duct construction.

2. Access Doors: Refer to Section 233300 for access door requirements.

C. Kitchen Grease (Type 1 Commercial) Hood Exhaust Air: Install per NFPA 96.

1. Construction: Single-wall Type 304 stainless sheet steel or carbon sheet steel when concealed. Single-wall Type 304 stainless sheet steel with No. 4 finish when exposed-to-view. Duct shall have minimum thickness of 16-gage.

2. Construction: Factory-fabricated, double-wall stainless steel with No. 4 finish when exposed-to-view.

3. Operating Pressures up to 3-inches w.g.

   a. SMACNA Duct Pressure Class: 4-inches w.g.

   b. SMACNA Seal Class: Welded seams, joints and penetrations.

   c. SMACNA Leakage Class: Liquid-tight.

D. Clothes Dryer Exhaust Air:

1. Construction: Single-wall aluminum sheet, minimum 0.020-inch thick and minimum 4-inches diameter, with a smooth interior finish and longitudinal seams.

2. Operating Pressures up to 1-inch w.g.

   a. SMACNA Duct Pressure Class: 2-inches w.g.

   b. SMACNA Seal Class: B

   c. SMACNA Leakage Class: 8

3.2. DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Duct Dimensions: Dimensions in the construction documents indicate as follows:

1. Rectangular Duct: Nominal inside width and height of the duct.

2. Round Duct: Nominal inside diameter of the duct.

3. Oval Duct: Nominal inside width and depth diameter (of the round sides connecting the flat portions) of the duct.

4. Double-Wall Duct: For double-wall duct, the inside is defined as the inner-duct.

C. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

D. Install ducts according to SMACNA’s “Duct Cleanliness for New Construction Guidelines”.

1. Store duct, fittings and accessories on pallets in a clean and dry location.

2. All sections of duct, fittings and accessories shall be sealed for shipping and storage. They may be sealed at all openings with polyethylene film, shrink-wrapped, bagged or equivalent. Exposed openings shall remain sealed until temporary filtration is in place.

3. Temporary filter media shall be installed on both return and exhaust ducts/inlets if system is operated for conditioning prior to occupancy.

4. Internal surfaces shall be wiped clean as each is installed to prevent construction dust and debris from accumulating.

E. Install round and flat-oval ducts in maximum practical lengths.

F. Install ducts with fewest possible joints.

G. Install factory or shop fabricated fittings for changes in direction, size, and shape and for branch connections.

H. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

I. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

J. Install ducts with a clearance of 1-inch plus allowance for insulation thickness.

K. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

L. Where ducts pass through non-fire-rated interior partitions and exterior walls, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

M. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements of the specifications and drawings for fire and smoke dampers.

N. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.3. DUCT WELDING

A. Duct welding materials and methods shall be in accordance with AWS Standard D9.1-90 Sheet Metal Welding Code.

B. Electrode material and flux shall be compatible with the sheet metal material being welded.

C. Re-coat any galvanizing damaged as a result of welding with a zinc-rich paint, such as Porter Zinc-Lock 351 – Gray.

D. Stainless Steel Ductwork Welding:

1. Welding Process: Welding process shall be inert gas shielded tungsten arc process. Electric current for welding shall be direct current, straight polarity (electrode negative and work positive).

2. Shielding and Purging: Shielding and purging gas shall be welding grade helium, argon or a mixture of both.

3. Electrodes: Electrodes shall be 2-percent thoriated tungsten conforming to AWS classification and complying with AWS A5.4, AWS A5.9, and AWS A5.12.

4. Grinding and Polishing: The inside and outside of welds shall have burrs and rough spots removed with a tungsten carbide file or grinder. Final polishing shall be with the proper grit (free of iron) abrasive grinder with flexible flap, drum or roll wheel.

3.4. INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.5. ADDITIONAL REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease and sloped a minimum of 2 percent to drain grease back to the hood.

B. Install residue traps with cleanouts at base of vertical risers. Cleanouts shall be located and arranged to be accessible for regular cleaning.

C. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 12 feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches from bottom of duct.

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

3.6. ADDITIONAL REQUIREMENTS FOR CLOTHES DRYER EXHAUST DUCT

A. Install duct in accordance the manufacturer’s recommended installation instructions whichever they are more stringent.

B. Provide a factory-fabricated aluminum dryer vent termination with an integral backdraft damper at the exterior termination. Bird and insect screens are not acceptable.

C. Support duct from building structure at minimum 4-foot on-center.

D. Provide a temporary cap on the interior duct opening until the clothes dryer is installed.

E. Provide protective galvanized steel shield plates, minimum 0.062-inches thick, to prevent penetrations of the duct. Locate shield plates on the finish face of all framing members where there is less than 1.5-inches between the duct and the finish face of the framing member. Shield plates shall extend 2-inches above sole plates and below top plates.

F. Transition ducts shall not be concealed by the building construction. Transition ducts shall be listed and labeled for their application and be no more than 8-foot long.

G. Penetrations through life-safety rated assemblies shall meet the requirements of UL 263 or ASTM E 119. Fire and/or smoke-rated dampers are not acceptable.

H. Provide permanent labels indicated the maximum equivalent length of exhaust duct.

3.7. 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.

5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," 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 maximum intervals of 10 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.8. CONNECTIONS

A. Make connections to equipment with flexible connectors.

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.9. PAINTING

A. Paint interior of all metal duct that is visible through registers and grilles and that does not have duct liner.

B. Paint exterior of all galvanized metal duct that is exposed-to-view. Do not paint stainless steel duct unless otherwise directed.

1. Exception: Do not paint duct in mechanical rooms, mezzanines or penthouses.

C. Painting Duct:

1. Clean duct of dirt, grease and lubricants with a non-hydrocarbon “green” cleaner.

2. Prime duct with 2 coats of water-based white acrylic primer paint designed for use with galvanized steel.

3. Finish duct with 2 coats of latex paint.

a. Exterior Duct Surfaces: Color and finish shall be chosen by the owner/ architect.

b. Interior Duct Surfaces: Flat black.

D. Apply paint and primer at the recommended spreading rate and film thickness as recommended by the paint manufacturer.

E. Apply paint and primer within the environmental conditions recommended by the paint manufacturer but not less than 55F; not more than 90F; and not more than 70% RH.

F. Mill phosphatized or bonderized ”paint grip” steel is not acceptable. Galvannealed sheet metal using a continuous hot-dipping method is an acceptable alternative.

3.10. FIELD QUALITY CONTROL

A. Engineer to inspect all ductwork at operating pressure prior to insulation for leakage. All leakage shall be repaired.

B. Perform tests and inspections.

C. Leakage Pressure Tests:

1. Test 100% of supply, return, exhaust, relief and ventilation duct at pressures equal to their maximum static pressure classifications. Do not over-pressurize systems above their maximum designed operating pressure.

a. Low pressure duct (2-inches w.g. or less) listed below shall be tested for leakage.

1) Return air duct for return plenum systems under negative pressure and greater than 30 ft. total length of duct.

2) Return air duct from the intake of blower coil units under negative pressure and greater than 30 ft. total length of duct.

3) Exhaust and Relief air duct under negative or positive pressure as per normal operation and greater than 30 ft total length of duct.

4) Outdoor and Ventilation air duct under negative pressure and greater than 30 ft. total length of duct.

5) Supply air duct from the discharge of terminal units, fan coil units and blower coil units under positive pressure and greater than 30 ft. total length of duct.

2. Test duct leakage per 2013 ASHRAE Fundamentals Handbook Chapter 21and 2016 ASHRAE HVAC Systems and Equipment Handbook Chapter 19 with an average leakage rate for each duct system as specified in Table 3 for the leakage class specified in Part 3 of this section.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

4. Test for leaks before applying external insulation.

5. Provide 10-day notice for testing.

6. Testing performed prior to the installation of duct accessories, such as dampers and access doors, is not valid. Alterations of the systems due to incomplete or non-conforming work made after testing will void previous test results and require new testing at no additional cost to the owner or engineer. Verify related work is complete before starting.

D. Leakage Light Tests:

1. Test 100% of commercial kitchen hood exhaust air duct. Perform leakage test using light complying with the current edition of the Mechanical Code and the following, whichever is stricter.

a. Perform the tests in low ambient light levels.

b. Pass a 2500 lumen light source, such as a 150-watt incandescent or 40 watt LED lamp, through the entire length of the duct.

c. Inspect 100% of all joints to ensure they are liquid-tight.

d. If light is detected at any point, remake and retest joints until all pass.

e. Once the duct is completely tested and proved compliant, allow the Owner and Engineer to witness the test.

E. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.

2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

F. Duct system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

END OF SECTION 233113

SECTION 233300 – METAL DUCT ACCESSORIES

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes air duct accessories including relief, volume, control and life-safety dampers; flexible ducts; flange and flexible connectors; turning vanes; duct-mounted access doors; and duct hardware.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

B. Close-Out Submittals:

C. Life-Safety Damper Inspection Reports: Document testing and results for all life-safety dampers including installation and operation inspection, engineer’s inspections and AHJ’s inspections.

1. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.3. EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed but no less than 10 total.

PART 2 - PRODUCTS

2.1. ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

C. Provide dampers constructed with materials matching the duct system.

1. Exception: Use Type 304 stainless steel in galvanized duct subject to moist airstreams such as humidifiers, locker room exhaust, pool rooms, steam autoclaves, etc.

2.2. MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60.

2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and No. 4 finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36-inches or less; 3/8-inch minimum diameter for lengths longer than 36-inches.

2.3. STATIC PRESSURE GAGES

A. Dial Gages: 3-1/2 inch diameter dial in metal case, diaphragm actuated, black figures on white background, front calibration adjustment, 2-percent of full scale accuracy.

B. Accessories: Static pressure tips with compression fittings for bulkhead mounting, 1/4-inch diameter tubing. Provide 3-way vent valves.

2.4. GRAVITY BALANCED BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Description: Gravity-balanced dampers for backdraft or pressure relief. Dampers shall have adjustable tension return spring; steel ball bearings; counter-weights and spring-assist kits for vertical flow applications; and bird screens. Unless otherwise indicated, dampers shall be rated for 2000 fpm maximum air velocity and 2-inches w.g. maximum system pressure.

1. Frame: Hat-shaped with welded corners or mechanically attached and mounting flange, constructed of one of the following to match the duct system material type for each: 12-gauge thick, galvanized sheet steel; 0.063-inch thick extruded aluminum; or 0.05-inch thick stainless steel.

2. Blades: Parallel-action, multiple single-piece blades, center pivoted, maximum 6-inch width, 0.025-inch thick, roll-formed aluminum with mechanically-locked neoprene blade seals and 0.20-inch diameter stainless steel blade axles.

2.5. BAROMETRIC RELIEF DAMPERS

A. Description: Barometric relief dampers for pressure relief. Dampers shall have return spring or adjustable tension counter-weight; stainless steel bearings; and bird screens. Unless otherwise indicated, dampers shall be rated for 2000 fpm maximum air velocity and 2-inches w.g. maximum system pressure.

1. Frame: Hat-shaped with welded corners or mechanically attached and mounting flange, constructed of one of the following to match the duct system material type for each: 16-gauge thick, galvanized sheet steel; 0.093-inch thick extruded aluminum; or 18-gauge stainless steel.

2. Blades: Parallel-action, multiple single-piece blades, center pivoted, maximum 6-inch width, 0.050-inch thick, roll-formed aluminum with mechanically-locked neoprene blade seals and 0.20-inch diameter stainless steel blade axles.

2.6. MANUAL VOLUME DAMPERS

A. Standard Rectangular, Steel, Manual Volume Dampers: Standard leakage rating suitable for horizontal or vertical volume control applications with molded synthetic bearings. Unless otherwise indicated, dampers shall be rated for 2000 fpm maximum air velocity and 2.5-inches w.g. maximum system pressure. Provide dampers equivalent to Ruskin MD35.

1. Frame: Hat-shaped with welded corners, constructed of 16-gauge thick, galvanized sheet steel, with flanges for wall attachments or flangeless for in duct installations.

2. Blades: Opposed-blade action, multiple single-piece blades, center-pivot, maximum 8-inch width, 16-gauge thick galvanized steel, galvanized steel blade axles and exposed linkage. Provide 2-inch handle extension wherever duct system will be insulated.

B. Standard Round, Steel, Manual Volume Dampers: Standard leakage rating suitable for horizontal or vertical volume control applications with molded synthetic bearings. Unless otherwise indicated, dampers shall be rated for 1500 fpm maximum air velocity and 2-inches w.g. maximum system pressure. Provide dampers equivalent to Ruskin MDRS25

1. Frame: Constructed of 20-gauge thick galvanized sheet steel, flangeless for in duct installations.

2. Blades: Single-blade, center-pivot, 20-gauge thick galvanized sheet steel, 0.375-inch diameter galvanized steel blade axle and 90-deg quadrant handle. Provide 2-inch handle extension wherever duct system will be insulated.

C. Damper Hardware: Zinc-plated, die-cast core with hand quadrant dial and handle made of 3/32-inch thick zinc-plated steel, and hexagon locking nut. Include elevated platform for insulated duct mounting.

1. Handle operation shall be painted orange.

2.7. CONTROL DAMPERS

A. Standard Low-Pressure Rectangular, Steel, Control Dampers: Standard leakage rated damper suitable for horizontal or vertical volume control applications with synthetic or stainless steel bearings. Dampers shall be rated for 2,000 fpm maximum air velocity, 2.5-inches w.g. maximum system pressure and maximum leakage of 10 cfm/sqft. at 1.0-inches pressure. Provide dampers equivalent to Ruskin CD35.

1. Frame: Hat-shaped with welded corners, constructed of 16-gauge thick, galvanized sheet steel, with flanges for wall attachments or flangeless for in duct installations.

2. Blades: Opposed-blade action, multiple single-piece blades, center-pivot, maximum 6-inch width, 16-gauge thick galvanized steel, galvanized steel blade axles and exposed linkage. Provide 2-inch handle extension wherever duct system will be insulated.

3. Applications:

   a. Operating Pressure: Up to 2.0-inches w.g.

   b. Operating velocity: Up to 1,500 fpm.

   c. Throttling: Opposed-blade type.

   d. Two-Position (Open/Closed): Parallel type.

B. Standard Medium-Pressure Rectangular, Steel, Control Dampers: AMCA Class 2 leakage damper suitable for horizontal or vertical volume control applications with oil-impregnated stainless steel bearings. Dampers shall be rated for 3,000 fpm maximum air velocity and 5.0-inches w.g. maximum system pressure. Provide dampers equivalent to Ruskin CD36.

1. Frame: Hat-shaped with welded corners, constructed of 16-gauge thick, galvanized sheet steel, with flanges for wall attachments or flangeless for in duct installations.

2. Blades: Opposed-blade action, multiple single-piece blades, center-pivot, maximum 6-inch width, 16-gauge thick galvanized steel, galvanized steel blade axles and exposed linkage. Provide 2-inch handle extension wherever duct system will be insulated.

3. Applications:

   a. Operating Pressure: Up to 4.0-inches w.g.

   b. Operating velocity: Up to 2,500 fpm.

   c. Throttling: Opposed-blade type.

   d. Two-Position (Open/Closed): Parallel type.

C. Standard Low-Pressure Round, Steel, Control Dampers: Standard rating suitable for horizontal or vertical volume control applications with molded synthetic bearings. Unless otherwise indicated, dampers shall be rated for 1,500 fpm maximum air velocity and 2.0-inches w.g. maximum system pressure. Provide dampers equivalent to Ruskin MDRS25.

1. Frame: Constructed of 20-gauge thick galvanized sheet steel, either with flanges on both sides or internal duct mounting.

2. Blades: Single-blade action, 20 gauge-thick steel, center-pivot, closed cell rubber edge seals and galvanized steel blade axles.

3. Applications:

a. Operating Pressure: Up to 1.0-inches w.g.

b. Operating velocity: Up to 1,000 fpm.

D. Medium-Pressure Round and Oval, Steel, Control Dampers: AMCA Class 2 damper suitable for horizontal or vertical volume control applications with stainless steel bearings. Unless otherwise indicated, dampers shall be rated for 4,000 fpm maximum air velocity and 10.0-inches w.g. maximum system pressure. Provide dampers equivalent to Ruskin CDR25 (round) / CDO25 (oval).

1. Frame: Constructed of 14-gauge thick galvanized sheet steel, either with flanges on both sides or internal duct mounting.

2. Blades: Single-blade action, 12 gauge-thick steel, center-pivot, closed cell rubber edge seals and galvanized steel blade axles.

3. Applications:

a. Operating Pressure: Up to 8.0-inches w.g.

b. Operating velocity: Up to 3,200 fpm.

2.8. LIFE-SAFETY DAMPERS

A. General Requirements:

1. Temperature Activation Rating: Fusible links and/or heat sensors shall be rated for 165 deg F in general air duct systems (up to 120 deg F) and rated for 212 deg F in high temperature duct systems (greater than 120 deg F) such as smoke control.

2. Frame Style: Rectangular life-safety dampers shall have Type B curtain-style blades outside the air stream except for tight locations where otherwise noted or pre-approved by the Engineer.

3. Minimum Dimensions: Damper height or width dimension shall be minimum 8-inches to allow a minimum 12-inch by 6-inch access door and adequate space to test and maintain damper, regardless of duct dimensions. Refer to 'Duct-Mounted Access Doors' in this section for more information about sizing.

4. Sidewall Grilles: Dampers installed behind sidewall grilles shall be fully serviceable through the grille.

B. Fire Dampers: 1-1/2 and 3-hour UL 555 and FM rated and labeled dynamic fire dampers suitable for horizontal or vertical applications with 4-inch w.g. closing rating static pressure class and minimum 2000 fpm rated velocity.

1. Horizontal dampers shall include stainless steel closure spring.

2. Frame: Factory-fabricated with roll-formed 20-gauge thick galvanized steel and mitered and interlocking corners.

3. Mounting Sleeve: Factory installed galvanized sheet steel, minimum thickness to suit application.

4. Blades: Roll-formed, interlocking, 20-gauge thick, galvanized sheet steel. In place of interlocking blades, use full-length, 20-gauge thick, galvanized-steel blade connectors.

2.9. TURNING VANES

A. Turning Vanes for Metal Ducts: Factory-fabricated, double-wall, curved airfoil-shaped blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting. Comply with details in SMACNA “HVAC Duct Construction Standards – Metal and Flexible”

2.10. DUCT-MOUNTED ACCESS DOORS

A. General: Factory-fabricated access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Doors: Factory-fabricated access doors shall be air-tight suitable for associated duct pressure and leakage classification. All doors shall be rigid and close fitting and include sealing gaskets and quick locking devices. Door construction materials shall match metal duct type, galvanized steel, stainless steel or aluminum.

a. Access doors must be installed prior to duct pressure and leakage testing. If the Engineer determines the access doors cannot meet the requirements of the testing, they shall be replaced with a higher quality door at the contractor’s expense.

b. Access panels with sheet metal screw fasteners are not acceptable.

2. Frames: Galvanized sheet steel, with bend-over tabs and foam or neoprene gaskets. Security chain to restrain door to frame.

3. Hinges and Latches:

a. Doors up to 12-inches Square: Secure with sash locks.

b. Doors up to 18-inches Square: Provide two hinges and two sash locks.

c. Doors up to 24 x 48 Inches: Three hinges and two compression latches with outside and inside handles.

d. Larger door sizes: Provide an additional hinge.

4. Vision Panels: 12-inch square wired-glass vision panels in all access doors larger than 6 sqft. and where noted, including:

a. Plenum Access Doors.

B. Standard Duct-Mounted Access Doors: Doors in uninsulated duct shall be single-wall. Doors in insulated duct shall be double-wall with 1-inch of mineral fiber or foam insulation fill.

1. Rectangular Duct-Mounted Access Doors: Rectangular and square access doors for rectangular and flat oval duct.

a. Life-Safety Damper Access: Doors installed to provide access to life-safety dampers shall be minimum 12-inches square.

1) Duct without a 14-inch or larger dimension shall transition to a size with at least one 14-inch dimension to allow for 12-inch square access door.

a) Exemptions: Sidewall grilles and ceiling radiation dampers.

2) Ducts with a dimension from 14 to 24-inches shall have square access doors 2-inches less than largest duct dimension.

3) Ducts with a dimension of 26-inches or larger shall have 24-inch by 24-inch duct access doors.

b. Equipment and Sensor Access: 12 x 6-inch rectangular access doors shall be used in 8-inch largest dimension ducts; 12 x 8-inch rectangular doors in up to 12-inch ducts; 12-inch square doors in up to 18-inch ducts; 18-inch square doors in up to 24-inch ducts; and 24-inch square doors in 26-inch and larger ducts.

2. Oval and Round Duct-Mounted Access Doors: Oval access doors for round and oval ducts. Equivalent to Ruskin ADR Series.

a. Door Sizes: 8-inch by 4-inch access doors shall be used in 4 and 6-inch diameter round ducts; 10-inch by 6-inch doors in 6 to 12-inch ducts; and 16-inch by 12-inch doors in 14-inch and larger ducts.

1) Life-Safety Damper Access: Transition round and oval duct to rectangular duct matching life-safety damper dimensions. Install access doors in accordance with Rectangular Duct-Mounted Access Doors paragraph above.

C. Plenum-Mounted Access Doors: Open outward for positive-pressure ducts and inward for negative-pressure ducts. Full height plenums shall have 72-inch tall x 30-inch wide door with vision panel and mounted between 4 and 12-inches above the floor unless otherwise indicated.

D. Grease Duct-Mounted Access Doors: Panel and frame constructed of minimum 0.0528-inch thickness carbon steel or 0.0428-inch stainless steel with stainless steel panel fasteners that do not penetrate the duct wall and grease-tight high-temperature ceramic-fiber gasket rated for 2000 deg F. Labeled according to UL 1978 and complies with NFPA 96. Rated for minimum pressure of 10-inches w.g. positive or negative.

2.11. DUCT TEST HOLES

A. Permanent Test Holes: Factory-fabricated, air-tight, flanged fittings with screw cap. Furnish extended neck fittings to clear insulation.

2.12. FLEXIBLE CONNECTORS

A. Materials: Flame-retardant or noncombustible fabrics.

B. Coatings and Adhesives: Comply with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch thick aluminum sheets. Provide metal compatible with connected ducts.

D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene with a minimum weight of 26 oz/sqyd; tensile strength of 480 lbf/inch in the wrap and 360 lbf/inch in the filling; and a service temperature range of (-) 40 deg F to 200 deg F.

E. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct. They shall be factory-fabricated for HVAC applications up to 10-inches w.g. of pressure.

F. Grounding Straps: Flexible braided copper grounding strips, flat or round, providing an equivalent ampacity of a #6 AWG conductor.

2.13. FLEXIBLE DUCTS

A. General: Flexible duct shall comply with UL 181, Class 1 and have flame spread rating of less than 25 and smoke developed rating of less than 50.

B. Non-Insulated, Flexible Duct: Aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire. Duct shall have 10-inch w.g. positive and 1-inch w.g. negative pressure ratings; maximum air velocity of 4000 fpm; and temperature rating of (-) 20 deg F to 210 deg F.

C. Insulated, Flexible Duct: Double-ply polyester film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film. Duct shall have 10-inch w.g. positive and 1-inch w.g. negative pressure ratings; maximum air velocity of 4000 fpm; and temperature rating of (-) 10 deg F to 160 deg F. Insulation value shall meet or exceed R-value of connected duct insulation.

D. Flexible Duct Connectors: Stainless steel bands with cadium-plated hex screws to tighten band with a worm gear action sized to suit duct size.

2.14. DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1. INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install static pressure gages to measure across filters and filter banks, (inlet to outlet). On multiple banks, provide manifold and single gage.

1. Provide instruments with scale ranges selected according to service with largest appropriate scale. Filter gauges shall be 0 to 2-inch scale.

D. Whether or not indicated on plans, install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel. Damper construction materials shall match duct system materials.

1. Volume damper handle positions shall match volume damper positions. If the damper is closed, the handle should be perpendicular to the direction of airflow. If the damper is open, the handle should be parallel to the direction of airflow.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install life-safety dampers according to UL listing and coordinate their location and adjacent installations to ensure they are fully accessible for maintenance and testing.

H. Access Doors: Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.

2. Upstream from duct filters.

3. At outdoor-air intakes and mixed-air plenums.

4. At drain pans and seals.

5. Downstream from control dampers, backdraft dampers, and equipment.

6. Adjacent to and close enough to fire dampers, to reset or reinstall fusible links. Access doors for access to fire dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.

7. Control devices requiring inspection.

8. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. Label access doors according to Section 230553 to indicate the purpose of access door.

K. Install temporary duct test holes as required for testing and balancing purposes. Cut or drill ducts. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

L. Install flexible connectors to connect ducts to equipment. Install flexible grounding strip(s) from equipment to duct.

M. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

N. Connect diffusers to ducts with up to 6-foot maximum lengths of flexible duct clamped or strapped in place, unless otherwise indicated.

O. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws and tape.

P. Install duct test holes where required for testing and balancing purposes.

Q. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2. CONTROL DAMPERS

A. Control Dampers for Air Handling Equipment:

1. Outside Air (OA) Dampers: Provide damper types noted in the air handling unit sections and on the drawings. Dampers sized for 2,000 FPM face velocity at full flow and 100 FPM at 5-percent flow.

   a. Opposed-blade type.

   b. Parallel-blade type. Orient blades to direct air flow away from coils and toward outside air flow to promote mixing.

2. Relief Air (RE) / Exhaust Air (EA) Dampers:

   a. Fan: Opposed-blade type sized for 2,000 FPM face velocity at full flow.

   b. Barometric: Parallel-blade type sized for 1,000 FPM face velocity at full flow.

3. Return Air (RA) Dampers: Parallel-blade type sized for 1,500 FPM face velocity at full flow. Orient blades to direct air flow away from coils and toward outside air flow to promote mixing.

3.3. FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.

2. Inspect locations of access doors and verify that purpose of access door can be performed.

3. Operate fire dampers to verify full range of movement and verify that proper heat-response device is installed.

4. Inspect turning vanes for proper and secure installation.

5. Life-Safety Damper Testing: Dampers shall be 100% tested and verified to be open and operational through their full range of movement. Damper testing shall be performed by contractor with minimum 5-years of experience in testing life-safety dampers. Within 2 weeks of written certification that all dampers are correct, Engineer shall inspect dampers prior to AHJ inspection.

a. Test Procedures:

1) Fire dampers with fusible links shall be tested by removing the fusible link. Observe that damper closes completely.

2) Fire dampers with firestats shall be tested with a heat gun. Observe that damper closes completely.

3) If any dampers do not close completely, correct installation and retest.

4) After verification of damper closing, verify that damper reopens to normal position without blockage of air flow. Reset fusible links and firestats. Close access door.

b. Test Report:

1) Provide written report to Engineer and signed by the responsible Contractor representatives.

2) Report shall list each fire damper with test results for each damper including time, date, and name of test technician for each test.

3) Report shall include a table showing each damper with a unique identification for each damper. Report shall include a notation of whether damper is in supply, return, exhaust or other type of duct.

4) Report shall include drawings showing the location of each damper on the floor plans.

3.4. DEMONSTRATION

A. Demonstrate re-setting of fire dampers for Owner and Engineer.

B. Provide Owner training in compliance with Section 230200.

END OF SECTION 233300

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SECTION 233400 – HVAC FANS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes centrifugal rooftop fans, cabinet fans, inline centrifugal fans, propellor fans, and terminal equipment centrifugal fans.

1.2. PERFORMANCE REQUIREMENTS

A. Operating Limits: Classify according to AMCA 99.

1.3. SUBMITTALS

A. Product Submittals: For each type of product indicated include rated capacities, operating characteristics, and furnished specialties and accessories. The product data shall also include the following: certified fan performance curves with system operating conditions indicated; certified fan sound-power ratings; motor ratings and electrical characteristics, plus motor and electrical accessories; material thickness and finishes; dampers, including housings, linkages, and operators; roof curbs; and fan speed controllers.

B. Close-Out Submittals:

1. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.4. QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

B. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

C. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

1.5. EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: Two set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1. GENERAL REQUIREMENTS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Greenheck Fan Corp.

2. Loren Cook Company

3. Twin City Fan and Blower

B. Description: Factory fabricated, assembled, tested, and finished, belt-driven or direct-driven (as scheduled) fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly and support structure with factory installed and wired service disconnect switch. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.

C. AMCA Compliance: Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal. Classify operating limits according to AMCA 99.

1. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210/ASHRAE 51, "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating."

D. Shafts: Fan shafts shall be statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning. Shafts shall be turned, ground, and polished hot-rolled steel with keyway and finished with an anti-corrosive coating. They shall be designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

E. Pre-lubricated and Sealed Shaft Bearings: Self-aligning, pillow-block type bearings rated for L10 at 100,000 hours.

1. Extend grease fitting to accessible location outside of unit.

2. Insulated bearings for all fan motors 100 hp and larger.

F. Belt Drives: Factory mounted, with adjustable alignment and belt tensioning, and with 1.5 service factor based on fan motor.

1. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.

2. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.

3. Belts: Oil resistant, non-sparking, and non-static V-belts; in matched sets for multiple-belt drives.

4. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

5. Motor Mount: Adjustable for belt tensioning.

G. Direct Drives: Factory-mounted with 1.2 service factor based on fan motor.

H. Motors: Comply with requirements of Section 230513.

I. Speed Controller: Where indicated, provide solid-state, factory-mounted, manual speed controller on 115V or 230V single-phase, direct-drive fans for air flow balancing.

J. Variable Frequency Controllers: Refer to Section 230514.

1. Variable frequency drives shall not be installed outdoors without supplemental cooling.

K. Motor Starters and Disconnects: Refer to Section 230511.

1. Disconnect Switch: Factory wired and mounted non-fusible type with thermal-overload protection mounted to the fan housing, unless otherwise indicated. Wiring shall be enclosed in aluminum conduit.

L. Dampers: Motor-operated, parallel blade aluminum dampers mounted in the curb base shall open when the fan starts and close when it stops. Refer to Section 233300.

1. Where indicated, provide counter-balanced backdraft dampers in lieu of motor-operated type.

M. Roof Curbs: Factory-fabricated welded-seam self-flashing roof curb to match fan and roof-slope, constructed of galvanized sheet metal with 1 1/2-inch pressure-treated wood nailer, water-tight gasket, 1 1/2-inches of rigid fiberglass insulation, damper tray, and finished with primer and powder baked white enamel.

1. Curb Height: 16-inches with a minimum of 12-inches above the finished roof surface.

2.2. CENTRIFUGAL ROOFTOP FANS

A. General Description: Rooftop fan with removable spun-aluminum dome top and outlet baffle; square one-piece aluminum base with venture inlet cone; fan wheel with aluminum hub and wheel with backward-inclined blades; and belt or direct-drive as scheduled. Outlet shall have removable 1/2-inch aluminum mesh birdscreen. The drive shall be equipped with an automatic belt tensioner.

B. Rooftop Dome-Type Downblast Centrifugal Fans: Greenheck G/GB Series, Loren Cook ACE Series, or Twin City BCRD/DCRD Series.

1. Application: General building exhaust systems.

C. Rooftop Grease-Type Upblast Centrifugal Fans: Fan housing shall have spun-aluminum discharge baffle to direct discharge air upward with rain drains. Provide with hinged-base, vented curb extension and grease capture and containment system. Vented curb extension shall extend the mounting height of the fan's discharge to minimum 40-inches above the finished roof surface to comply with NFPA 96, but no higher than 44-inches unless otherwise noted. Greenheck CUE/CUBE Series, Loren Cook VCR Series, or Twin City BCRUR/DCRUR Series.

1. Application: Grease hood exhaust systems.

2.3. CABINET FANS

A. General Description: Cabinet style fan with steel housing lined with acoustical insulation; removable centrifugal fan wheel; and belt or direct-drive as scheduled. Electrical connection shall be hard-wired. Cord and plug wiring is not acceptable unless specifically noted on the equipment schedule.

B. In-Line Cabinet Fan: Greenheck CSP/SP Series, Loren Cook Gemini Series, or Twin City TL/DB Series.

1. Applications: General exhaust air systems.

C. Ceiling Cabinet Fan: Provide fan with white painted aluminum ceiling grille; plastic grilles are not acceptable. When located in fire-rated ceiling assemblies, provide with ceiling radiation damper that complies with Section 233300. Greenheck CSP/SP Series, Loren Cook Gemini Series, or Twin City TL/DB Series.

1. Applications: General exhaust air systems.

2.4. IN-LINE CENTRIFUGAL FANS

A. General Description: In-line centrifugal fan with split spun-aluminum housing with aluminum straightening vanes; inlet and outlet flanges; support bracket for floor, sidewall or ceiling mounting; fan wheel with cast-aluminum hub and aluminum airfoil blades; and belt or direct-drive as scheduled.

B. In-Line Square Centrifugal Fan: Greenheck SQ/BSQ Series, Loren Cook SQ Series, or Twin City BSI/DSI Series.

1. Applications:

2.5. CENTRIFUGAL FANS

A. Description: Fans included in packaged and terminal units shall meet the requirements of this section.

B. Housings: Horizontally-split, bolted-flange curved-scroll housing with shaped cutoff, flanged spun inlet cone and flanged outlet. Panel Bracing shall be steel angle or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.

C. Centrifugal Fan Wheels:

1. Airfoil Wheels: Fan wheels shall be single-width single-inlet (SWSI) and double-width double-inlet (DWDI) construction with curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

2. Backward-Inclined Wheels: Fan wheels shall be single-width single-inlet (SWSI) and double-width double-inlet (DWDI) construction with curved inlet flange; backplate; backward-inclined blades; fastened to shaft with set screws; and cast-iron or cast-steel hub riveted to backplate welded or riveted to flange and backplate.

3. Forward-Curved Wheels: Fan wheels shall be black-enameled or galvanized-steel construction with inlet flange; backplate; shallow blades with inlet and tip curved forward in direction of airflow; cast-steel hub swaged to backplate and fastened to shaft with set screws; and mechanically secured to flange and backplate.

4. Plenum Fan Wheels: Airfoil wheel shall be single-width single-inlet (SWSI) construction with heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

5. Plug Fan Wheels: Airfoil wheel shall be single-width-single-inlet (SWSI) construction with smooth-curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

PART 3 - EXECUTION

3.1. GENERAL INSTALLATION

A. Install power ventilators level and plumb.

B. Equipment Mounting:

1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548.

C. Secure roof-mounted fans to roof curbs with cadmium-plated hardware.

D. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

E. Support suspended units from structure using threaded steel rods and spring hangers with vertical-limit stops having a static deflection of 1 inch. Vibration-control devices are specified in Section 230548.

F. Install units with clearances for service and maintenance.

G. Label units according to requirements specified in Section 230553.

3.2. CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300.

B. Install ducts adjacent to fans to allow service and maintenance.

C. Ground equipment according to Division 26.

D. Connect wiring according to Division 26.

3.3. FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Verify that shipping, blocking, and bracing are removed.

2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

3. Verify that cleaning and adjusting are complete.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.

5. Adjust belt tension.

6. Adjust damper linkages for proper damper operation.

7. Verify lubrication for bearings and other moving parts.

8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.

10. Shut unit down and reconnect automatic temperature-control operators.

11. Remove and replace malfunctioning units and retest as specified above.

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. Comply with requirements in Section 230593 for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow. Coordinate with the TAB Contractor.

E. Lubricate bearings.

END OF SECTION 233400

SECTION 233600 – AIR TERMINAL UNITS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes single-duct air terminal units.

1.2. SUBMITTALS

A. Product Submittals: For air terminal units, include rated capacities, furnished specialties, sound-power ratings, and accessories.

1. Shop Drawings: For air terminal units. Include plans, elevations, sections, details, and attachments to other work.

a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

b. Wiring Diagrams: For power, signal, and control wiring.

B. Close-Out Submittals:

1. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.

1.3. QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

B. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

C. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

1.4. EXTRA MATERIALS

PART 2 - PRODUCTS

2.1. AIR TERMINAL UNITS

A. Manufacturers: Provide products that comply with the construction documents and are manufactured by one of the following:

1. Metalaire
2. Nailor Industries
3. Price
4. Titus

B. Heating Water Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1-inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

C. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

D. Direct Digital Controls: Bidirectional damper operator and microprocessor-based controller with integral airflow transducer. Control devices shall be compatible with temperature controls specified in Section 230900. Coordinate them with the DDC provider.

1. Damper Actuator: 24 V, powered closed.

2. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet(s).

2.2. SINGLE-DUCT AIR TERMINAL UNITS

A. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

1. Heating Coil Position: Unit discharge (full flow across coil).

B. Casing: 20 gage galvanized sheet steel with continuously sealed seams and joints. Leakage shall not exceed 2 percent of nominal airflow at 3-inch wg inlet static pressure.

1. Casing Lining: Adhesive attached, 1-inch thick, closed cell foam insulation complying with UL 181 erosion requirements and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84. Cover liner with nonporous fire-resistant reinforced aluminum FSK facing or mylar.

C. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.

2. Damper Position: Normally closed (unless otherwise noted).

D. Power Transformer: Factory-installed 24 V transformer mounted inside control panel enclosure. Coordinate power source voltage with electrical system indicated.

2.3. HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Steel Cables: Stainless steel complying with ASTM A 492.

C. 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.

D. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

E. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

2.4. SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to ARI 880.

B. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

C. Sound criteria shall be based on 1 1/2-inches wg pressure drop unless otherwise noted.

PART 3 - EXECUTION

3.1. INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Install air terminal units at 24-inches above finished ceiling to provide maintenance access.

D. Connect ducts to air terminal units according to Section 233113.

1. Install supply inlet duct with minimum straight length of 4 times duct diameter or greater as recommended by manufacturer. Do not use flexible duct.

E. Install piping adjacent to air terminal unit to allow service and maintenance.

F. Hot-Water Piping: In addition to requirements in Section 232113 and Section 232116 connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

G. Insulate hydronic heating coils.

H. Maintain minimum 36-inch clearance for 120/208V power or 42-inch clearance for 277/480V power as required by the National Electric Code on the control panel and control valve side to provide maintenance access.

I. Maintain clear space between the ceiling and the top of each terminal unit. Coordinate all clearances with other trades. Ensure access doors can be opened fully and all valves, dampers and devices can be easily reached and actuated.

3.2. HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Support terminal units independently from duct. Comply with Section 230529 for hangers and supports.

C. 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.

D. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.

1. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.

E. Hangers Exposed to View: Threaded rod and angle or channel supports.

1. 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.

3.3. IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 for equipment labels and warning signs and labels.

3.4. DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

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SECTION 233713 – DIFFUSERS, REGISTERS AND GRILLES

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes duct, ceiling, wall and floor-mounted air inlets and outlets.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.

2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

1.3. QUALITY ASSURANCE

A. Comply with NFPA 90A and NFPA 90B.

PART 2 - PRODUCTS

2.1. METAL DIFFUSERS, GRILLES & REGISTERS

A. Manufacturers: Provide products that comply with the construction documents and are manufactured by one of the following, unless otherwise noted in this section:

1. Metalaire

2. Nailor Industries

3. Price

4. Titus

B. General Requirements: Devices shall be specifically designed for variable air volume flows. Insulate backpan. Border type shall match each installation. Ceiling, wall, sill or duct-mounting as indicated. Face and neck dimensions as indicated. Inside of each backpan and duct plenum shall be painted flat black so that there is no visible metal from the face.

C. Materials: Provide devices constructed of the following materials unless otherwise indicated.

1. Material: Steel, aluminum, or stainless steel as noted.

2. Finish: Baked enamel, anodized aluminum, or primed-for-paint as noted.

a. Color: White, unless otherwise noted.

D. Volume Dampers: Provide manual volume damper at each air inlet or outlet branch duct tap, whether shown on the drawings or not, regardless of the diffuser, grille or register having an integral damper unless specifically noted otherwise. Dampers shall comply with Section 233300.

2.2. SUPPLY AIR DIFFUSERS

A. Square Louvered Face Ceiling Diffuser: Three cone, louvered, full-face diffuser with adjustable vane 360-degree discharge pattern, equalizing grid and foam rubber gasket. Where indicated, provide opposed-blade neck mounted manual volume damper that is operable from the diffuser face. Titus TMSA series or equal.

B. Airfoil Blade Grille: Double-deflection, adjustable, airfoil blade grille with front horizontal and rear vertical blades spaced at 3/4-inch. The blades shall be at 0-degree or 45-degree deflection as indicated. Where indicated, provide opposed-blade neck mounted manual volume damper that is operable from the diffuser face. Titus 272 series or equal.

2.3. RETURN, EXHAUST AND TRANSFER AIR GRILLES AND REGISTERS

A. Square Perforated Face Ceiling Grille: Perforated flush face grille with equalizing grid, foam rubber gasket and pre-formed insulation blanket. Provide backpan with duct connection collar where connected to ductwork. Where indicated, provide opposed-blade neck mounted manual volume damper that is operable from the diffuser face. Titus PAR series or equal.

B. Standard Blade Grille: Single-deflection, fixed, standard blade grille with front horizontal and rear vertical blades spaced at 3/4-inch. The blades shall be at 0-degree or 35-degree deflection as indicated. Where indicated, provide opposed-blade neck mounted manual volume damper that is operable from the grille face. Titus 350 series or equal.

C. Heavy Duty Blade Grille: Fixed deflection, heavy-duty grille with front horizontal blades and rear vertical supports at minimum 6-inch spacing. The blades shall be at 0-degree or 35 to 45-degree deflection as indicated. Where indicated, provide opposed-blade neck mounted manual volume damper that is operable from the grille face. Titus 30/33/60/63 series or equal.

2.4. SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1. EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.2. INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

D. Diffusers, registers and grilles shall be supported at two (2) opposite ends to the building steel/concrete frame or floor decking. Supports shall be provided with the same type of wire as used to support lay-in ceiling track.

E. Insulate diffusers, grilles and registers to prevent condensation. Coordinate insulation with Section 230713.

1. Insulate the plenum box for all linear and slot supply air diffusers and grilles.

2. Insulate the backpan of all surface-mounted supply air diffusers and grilles.

3. Insulate the backpan of all surface-mounted return / exhaust air grilles and registers where the connected ductwork penetrates the building’s thermal and vapor barrier or is routed through unconditioned spaces such as attics, mechanical rooms, basements and crawl spaces.

3.3. ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713

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SECTION 233723 – GRAVITY VENTILATORS

PART 1 - GENERAL

1.1. SUMMARY

A. This section includes roof hoods.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1.3. COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided and standing seam metal roof provider.

PART 2 - PRODUCTS

2.1. MATERIALS

A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5 or T-52.

B. Aluminum Sheet: ASTM B 209, Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.

C. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 zinc coating, mill phosphatized.

D. Stainless-Steel Sheet: ASTM A 666, Type 304 with No. 4 finish.

E. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.

1. Use types and sizes to suit unit installation conditions.

2. Use Phillips flat head screws for exposed fasteners unless otherwise indicated.

F. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.

2.2. GENERAL REQUIREMENTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck Fan Corp.

2. Loren Cook Company.

3. PennBarry

4. Twin City Fan and Blower

B. AMCA Compliance: Louvered-penthouses and roof hoods shall comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal.

C. Dampers: Motor-operated, parallel blade aluminum dampers mounted in the curb base shall open when the associated fan starts and close when it stops. Refer to Section 233300.

1. Where indicated, provide counter-balanced backdraft dampers in lieu of motor-operated type.

D. Roof Curbs: Factory-fabricated welded-seam self-flashing roof curb to match ventilator and roof-slope, constructed of galvanized sheet metal with 1 1/2-inch pressure-treated wood nailer, water-tight gasket, 1 1/2-inches of rigid fiberglass insulation, damper tray, and finished with primer and powder baked white enamel.

1. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match ventilator, used to anchor unit to the curb, and designed for loads at project site. Comply with requirements in Section 230548 for wind-load requirements.

2. Curb Height: 24-inches with a minimum of 12-inches above the finished roof surface.

2.3. ROOF HOODS

A. General Description: Factory-fabricated, roof hood for air intake or discharge as indicated constructed with minimum 0.063-inch thick aluminum base and minimum 0.050-inch thick reinforced hood. Inlets and outlets shall have removable 1/2-inch aluminum mesh birdscreen.

PART 3 - EXECUTION

3.1. INSTALLATION

A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.

B. Install gravity ventilators with clearances for service and maintenance.

C. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

D. Install concealed gaskets, flashings, joint fillers, and insulation.

E. Label gravity ventilators according to requirements specified in Section 230553.

F. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

3.2. CONNECTIONS

A. Duct installation and connection requirements are specified in Section 233113. Drawings indicate general arrangement of ducts and duct accessories.

END OF SECTION 233723

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SECTION 233813 – COMMERCIAL KITCHEN HOODS

PART 1 - GENERAL

1.1. SUMMARY

A. This section includes Type I commercial kitchen hoods for grease laden vapor exhaust applications.

1.2. SUBMITTALS

A. Delegated Design Submittals: Signed and sealed by a qualified professional engineer.

1. Show plan view, elevation view, sections, roughing-in dimensions, service requirements, duct connection sizes, and attachments to other work.

2. Show cooking equipment plan and elevation to confirm minimum code-required overhang.

3. Indicate performance, exhaust and makeup air airflow and pressure loss, at actual Project-site elevation.

4. Indicate method of attaching hangers to building structure.

5. Show exhaust and makeup air ducts, and fittings connecting to hoods.

6. Show water-supply and drain piping.

7. Show control cabinets.

8. Show fire-protection piping, actuation devices, and manual control devices.

9. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

10. Design Calculations: Calculate requirements for selecting seismic restraints.

11. Wiring Diagrams: Power, signal, and control wiring.

12. Piping Diagrams: Detail fire-suppression piping and components and differentiate between manufacturer-installed and field-installed piping. Include roughing-in requirements for drain connections. Show cooking equipment plan and elevation to illustrate fire-suppression nozzle locations.

B. Qualification Submittals:

1. Welding certificates.

C. Product Submittals: For each type of product indicated.

1. Hoods.

2. Grease removal devices.

3. Fire-suppression systems.

4. Lighting fixtures.

D. Construction Submittals:

1. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items. Show the following:

    a. Relative location of ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings to hoods and accessory equipment.

    b. Roof framing and support members for duct penetrations.

    c. Ceiling suspension assembly members.

    d. Size and location of initial access modules for acoustical tile.

2. Field test results.

E. Close-Out Submittals:

1.3. QUALITY ASSURANCE

A. Listed Hood: A hood tested according to UL 710 by a testing agency acceptable to authorities having jurisdiction.

B. Engineering Responsibility: Preparation of Shop Drawings and comprehensive engineering analysis by a qualified professional engineer.

C. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports; and AWS D9.1, "Sheet Metal Welding Code," for joint and seam welding.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. NSF Compliance: Fabricate hoods according to NSF 2, "Food Equipment."

F. SMACNA Compliance:

1. Comply with SMACNA's "Kitchen Equipment Fabrication Guidelines," Appendix 1, "Guidelines for Seismic Restraints of Kitchen Equipment."

2. Fabricate hoods to comply with SMACNA's "HVAC Duct Construction Standards: Metal and Flexible," second edition.

G. Design and installation of the fire suppression system for the Type I Hoods shall comply with NFPA 17A.

H. Site Work Coordination: Coordinate manual pull stations and associated in-wall conduit with masonry wall contractor prior to start of site work. Surface-mounted pull-station conduit is not acceptable.

1.4. COORDINATION

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

B. Coordinate fabrication with approved food service equipment Shop Drawings for equipment located below hoods and connected to UDS.

1.5. EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Furnish one complete set of grease removal devices.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

A. Manufacturers: Provide products by one of the following:

1. Commercial Kitchen Hoods:

a. Accurex

b. Captive-Aire Systems.

c. Greenheck.

2. Wet-Chemical Fire-Suppression Systems:

a. Ansul Inc.

b. Badger Fire Protection, Inc.

c. Fenwall Safety Systems, Inc.

d. Pyro Chem, Inc.

e. Hood Manufacture’s Listed Wet-Chemical Fire-Suppression System.

2.2. HOOD MATERIALS

A. Stainless-Steel Sheet: ASTM A 666, Type 304.

1. Minimum Thickness: 0.03 inch.

2. General: Comply with SSINA's "Finishes for Stainless Steel" for recommendations for applying and designating finishes.

3. Remove tool and die marks and stretch lines or blend into finish. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.

4. Concealed Stainless-Steel Surfaces: ASTM A 480/A 480M, No. 2B finish (bright, cold-rolled, unpolished finish).

5. Exposed Surfaces: ASTM A 480/A 480M, No. 4 finish (bright, directional polish).

6. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

B. Zinc-Coated Steel Shapes: ASTM A 36/A 36M, zinc coated according to ASTM A 123/A 123M requirements.

C. Sealant: ASTM C 920; Type S, Grade NS, Class 25, Use NT. Elastomeric sealant shall be NSF certified for commercial kitchen hood application. Sealants, when cured and washed, shall comply with requirements in 21 CFR, Section 177.2600, for use in areas that come in contact with food.

1. Color: As selected by Architect from manufacturer's full range.

2. Backer Rod: Closed-cell polyethylene, in diameter larger than joint width.

D. Sound Dampening: NSF-certified, nonabsorbent, hard-drying, sound-deadening compound for permanent adhesion to metal in minimum 1/8-inch thickness that does not chip, flake, or blister.

E. Gaskets: NSF certified for end-use application indicated; of resilient rubber, neoprene, or PVC that is nontoxic, stable, odorless, nonabsorbent, and unaffected by exposure to foods and cleaning compounds, and passes testing according to UL 710.

2.3. HOOD FABRICATION, GENERAL

A. Welding: Use welding rod of same composition as metal being welded. Use methods that minimize distortion and develop strength and corrosion resistance of base metal. Make ductile welds free of mechanical imperfections such as gas holes, pits, or cracks.

1. Welded Butt Joints: Full-penetration welds for full-joint length. Make joints flat, continuous, and homogenous with sheet metal without relying on straps under seams, filling in with solder, or spot welding.

2. Grind exposed welded joints flush with adjoining material and polish to match adjoining surfaces.

3. Where fasteners are welded to underside of equipment, finish reverse side of weld smooth and flush.

4. Coat concealed stainless-steel welded joints with metallic-based paint to prevent corrosion.

5. After zinc-coated steel is welded, clean welds and abraded areas and apply SSPC-Paint 20, high-zinc-dust-content, galvanizing repair paint to comply with ASTM A 780/A 780M.

B. For metal butt joints, comply with SMACNA's "Kitchen Equipment Fabrication Guidelines."

C. Where stainless steel is joined to a dissimilar metal, use stainless-steel welding material or fastening devices.

D. Form metal with break bends that are not flaky, scaly, or cracked in appearance; where breaks mar uniform surface appearance of material, remove marks by grinding, polishing, and finishing.

E. Sheared Metal Edges: Finish free of burrs, fins, and irregular projections.

F. In food zones, as defined in NSF, fabricate surfaces free from exposed fasteners.

G. Cap exposed fastener threads, including those inside cabinets, with stainless-steel lock washers and stainless-steel cap (acorn) nuts.

H. Fabricate pipe slots on equipment with turned-up edges sized to accommodate service and utility lines and mechanical connections.

I. Fabricate enclosures, including panels, housings, and skirts, to conceal service lines, operating components, and mechanical and electrical devices including those inside cabinets, unless otherwise indicated.

J. Fabricate equipment edges and backsplashes according to SMACNA's "Kitchen Equipment Fabrication Guidelines."

K. Fabricate enclosure panels to ceiling and wall as follows:

1. Fabricate panels on all exposed sides with same material as hood and extend from ceiling to top of hood canopy and from canopy to wall.

2. Wall Offset Spacer: Minimum of 3-inches.

3. Wall Shelves and Over-Shelves: Fabricate according to SMACNA's "Kitchen Equipment Fabrication Guidelines," with minimum 0.0625-inch-thick, stainless-steel shelf tops.

2.4. TYPE I EXHAUST HOOD FABRICATION

A. Weld all joints exposed to grease with continuous welds and make grease removal devices and makeup air diffusers easily accessible for cleaning.

1. Hoods shall be listed and labeled, according to UL 710, by a testing agency acceptable to authorities having jurisdiction.

2. Include access panels as required for access to fire dampers and fusible links.

3. Exhaust-Duct Collars: Minimum 0.0625-inch-thick stainless steel at least 3 inches long, continuously welded to top of hood and at corners.

B. Hood Configuration: Exhaust air.

1. Makeup air shall be introduced as shown on the drawings.

C. Hood Style: Double-island canopy.

D. Grease Removal Devices: Removable, stainless-steel, filter/baffle grease filters with spring-loaded fastening. Fabricate with minimum 0.0781-inch-thick stainless steel for filter frame and removable collection cup and trough. Exposed surfaces shall be pitched to drain to collection cup. Filters/baffles shall comply with UL 1046, "Grease Filters for Exhaust Ducts."

E. Removable Grease Extractor: Removable, stainless-steel extractor, at least 0.0781 inch thick. Hood with extractor must be tested according to UL 710.

F. Light Fixtures: UL-listed, surface-mounted, LED fixtures with lenses sealed vapor tight. Wiring shall be installed in stainless-steel conduit on hood exterior. Number and location of fixtures shall provide a minimum of 70 fc on cooking surface below hood.

1. Switches for main kitchen hoods shall be mounted on UDS.

2. LED Lighting Fixtures: 4000K color temperature.

G. Wet-Chemical Fire-Suppression System: Pre-engineered distribution piping designed for automatic detection and release or manual release of fire-suppression agent by hood operator. Fire-suppression system shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

1. Steel Pipe, NPS 2 and Smaller: ASTM A 53/A 53M, Type S, Grade A, Schedule 40, plain ends.

2. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300.

3. Pipe Covers: Chrome-plated aluminum tubing.

4. Piping, fusible links and release mechanism, tank containing the suppression agent, and controls shall be factory installed. Controls shall be in stainless-steel control cabinet mounted on UDS.

Furnish manual pull station for wall mounting adjacent to hood. Exposed piping shall be covered with stainless-steel sleeves. Exposed fittings shall be chrome plated. Pull station and associated conduit shall be recessed in-wall type. Surface-mounted station and exposed conduit are not acceptable.

5. Liquid Extinguishing Agent: Noncorrosive, low-pH liquid.

6. Furnish an electric-operated, gas shutoff valve with clearly marked open and closed indicator for field installation.

7. Fire-suppression system controls shall be integrated with controls for fans, lights, and fuel supply and located in a single cabinet for each group of hoods immediately adjacent.

8. Wiring shall have color-coded, numbered terminal blocks and grounding bar. Spare terminals for fire alarm, optional wiring to start fan with fire alarm, red pilot light to indicate fan operation, and control switches shall all be factory wired in control cabinet with relays or starters.

H. Hood Controls: Single, UDS-mounting control cabinet shall control groups of adjacent hoods and shall be fabricated of stainless steel.

1. Exhaust Fan: On-off switches shall start and stop the exhaust fan. Interlock exhaust fan with makeup air supply fan to operate simultaneously. Interlock exhaust fan with fire-suppression system to operate fans during fire-suppression-agent release and to remain in operation until manually stopped. Motor starters shall comply with section 230511 “HVAC Electrical Provisions” and Division 26 requirements.

2. High-Temperature Control: Alarm shall sound and cooking equipment shall shut down before hood discharge temperature rises to actuation temperature of fire-suppression system.

3. Refer to mechanical drawings for additional control requirements.

2.5. UTILITY DISTRIBUTION SYSTEM

A. A Utility Distribution System shall be provided as indicated on drawings. Systems shall have two vertical risers, one on each end, with one dedicated to electrical and the other to plumbing. The horizontal distribution raceway between the risers shall be separated into electrical and plumbing compartments and each shall be completely enclosed and water tight with removable access panels. The risers and raceway shall be constructed of 16 gauge, type 304 stainless steel, #4 finish. A circuit protected dual convenience outlet shall be provided on each riser. Service connections shall be located behind easily removable access panels.

1. Unit(s) shall be ETL Listed to US and Canadian Standards, NSF Listed, AGA and MA approved.

2. Bus bar systems: Electrical power shall be fed through the main circuit breaker to the bus bar system in the raceway. Each appliance is fed from the bus bar through individually sized circuit breakers located along the raceway. Individual circuit breakers shall be mounted on interchangeable plates for ease of service and relocation.

3. Plumbing Riser: The plumbing riser shall house manual (quarter-turn) shut-off valves for each incoming main supply line located in the UDS. The plumbing manifolds shall be provided with stub-outs along the raceway for the individual plumbing connections. Each stub-out shall be equipped with a manual (quarter-turn) shut-off valve.

4. Expandability: All electrical systems are designed for additional capacity for future expansion or upgrade of connected appliances.

5. Serviceability and Accessibility: Lift-out doors shall provide easy access to risers without moving cooking equipment, in most cases. Removable panels provided along the length of the raceway shall allow access to either plumbing or electrical compartments.

6. Electric Outlets and Cord Sets: All outlets shall provide moisture resistant covers and have been sized per NEMA standards. Each is supplied with a matching cord and plug set. Twist-lock sets are standard in island applications. All 120V, single phase 15 and 20 amp receptacles are DCO-GFI.

7. Main Disconnect: One point disconnect through a main circuit breaker equipped with a 120 VAC rated shunt trip provided in the riser.

8. Gas Solenoid Valve: Electrical valves shall be provided with a manual reset button and time delay relay to prevent pilot lights from going out in momentary power outages.

9. Shunt Trip: Shall be provided with each main breaker.

10. Appliance Protection: Each electrical outlet connection shall be protected with an individual circuit breaker.

11. Dual Convenience Outlets: Located at each riser with integral ground fault protection.

12. Fire/Fuel Shutoff: In compliance with NFPA 96, terminal connection points shall be provided for field wiring to the fire protection system to shut off fuel sources and power in the event of a fire.

13. Emergency Kill Switch: Single point shutdown of electrical power and electrical gas valve(s).

B. Electrical:

1. Bus Bar Systems: The electrical raceway shall be a four (4) conductor copper bus bar system having balanced load and phases and shall be completely isolated from the plumbing supply manifolds. Point of use circuit breakers shall be mounted on connection plates which are located on the peaked top of the raceway and protected by a water resistant stainless steel hinged cover. The breakers shall be easily accessible to the operator. The connection plates shall be easily interchangeable with spare blank plates which shall be provided for future expansion or changes. A main circuit breaker with a built-in 120 VAC rated shunt trip shall be furnished in the electrical riser and require a single point incoming connection. Terminal block connections shall be provided for field interconnection between the shunt trip and the fire protection system for power shut-off in the event of a fire.

C. Plumbing:

1. The plumbing compartment shall be completely isolated from the electrical with all piping labeled.

2. Cold water and steam supply and return manifolds shall be insulated.

3. All incoming service connections shall be provided with 1/4 shut-off valve. Each branch connection shall be provided with 1/4 turn shut-off valve, with color coded hoses, and located at each equipment location.

4. Color coded quick disconnect hoses are provided for connection to equipment.

5. Cold water piping, including branch connections, shall be type "L" copper tubing. All fittings will be copper sweat soldered (95-5 type).

6. Gas and steam piping, including branch connections, shall be threaded black iron. There shall be a drip tee on the incoming gas end. The gas manifold shall be furnished with either an electrical or mechanical gas valve which shall be field interlocked with the fire protection system to shut off fuel sources in the event of a fire. Electrical gas valves shall be furnished with a manual gas reset button and time delay relay to prevent pilot lights from going out in momentary power outages, located in the UDS riser.

D. Gas Equipment:

1. All gas equipment shall conform to local-Code requirements

a. Manifold (single): 3/4" to 3" IPS

b. 1/4 turn manual shut-off valve on manifold

c. Quick disconnect hoses: 1/4" to 1-1/4", up to 6' long

d. Quick disconnect fittings: 1/4" to 1-1/4" with 1/4 shut-off valves

E. Cold Water:

1. Manifold: 3/4" to 1" IPS

2. 1/4 turn manual shut-off valve on manifold

3. Quick disconnect hoses: 1/4" to 1", up to 6' long

4. Quick disconnect fittings: 1/4" to 1" with 1/4 shut-off valves

5. 1/4 turn manual valves on manifolds

6. Quick disconnect hoses: 1/4" to 1-1/4", up to 6' long

7. Quick disconnect fittings: 1/4" to 1-1/4" with 1/4 shut-off valve

F. Factory Tested: Unit(s) shall be operated, tested, and set at the factory using job-site conditions for electrical and gas input. All operating and safety controls shall be tested and set at the factory.

G. Service and Parts: The supplier shall furnish gas piping schematics, as-built wiring connection and control-circuit diagrams, dimension sheets and a full description of the unit(s). Service manuals showing service and maintenance requirements, shall be provided with each unit.

PART 3 - EXECUTION

3.1. EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting installation.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before equipment installation.

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

3.2. INSTALLATION

A. Install hoods level and plumb.

B. Install manual pull-station conduit in-wall. Surface-mounted conduit in not acceptable. Coordinate final pull station location(s) with Owner and Review with AHJ prior to start of site work.

C. Complete field assembly of hoods where required.

1. Make closed butt and contact joints that do not require filler.

2. Grind field welds on stainless-steel equipment smooth, and polish to match adjacent finish. Comply with welding requirements in Part 2 "General Hood Fabrication" Article.

D. Install hoods and associated services with clearances and access for maintaining, cleaning, and servicing hoods, grease removal devices, and fire-suppression systems according to manufacturer's written instructions and requirements of authorities having jurisdiction.

E. Make cutouts in hoods where required to run service lines and to make final connections.

F. Securely anchor and attach items and accessories to walls, floors, or bases with stainless-steel fasteners, unless otherwise indicated.

G. Install hoods to operate free from vibration.

H. Install seismic restraints according to SMACNA's "Kitchen Equipment Fabrication Guidelines," Appendix 1, "Guidelines for Seismic Restraints for Kitchen Equipment."

I. Install trim strips and similar items requiring fasteners in a bed of sealant. Fasten with stainless-steel fasteners at 48 inches o.c. maximum.

J. Install sealant in joints between equipment and abutting surfaces with continuous joint backing, unless otherwise indicated. Provide airtight, watertight, vermin-proof, sanitary joints.

K. Install light fixtures with manufacturer’s recommended standard light output, in equipment with integral lighting.

3.3. CONNECTIONS

A. Piping installation requirements are specified in other Division 22 and 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine with clearance to allow service and maintenance.

C. Install reduced-pressure backflow preventer on washer-water supply. Backflow preventer is specified in Division 22 Section "Plumbing Specialties."

D. Install washer-water drain piping full size of hood connection to an adjacent floor drain or floor sink.

E. Makeup Water Connection: Comply with applicable requirements in Division 22 "Domestic Water Piping" and “Plumbing Valves” sections for valves and accessories on piping connections to water-cooled units.

F. Duct Connections: Comply with applicable requirements in Division 23 Section "Duct Accessories" for flexible connectors on makeup air supply duct. Weld exhaust-duct connections.

G. Fire-Suppression Piping: Install piping connections for remote-mounted suppression systems according to NFPA 17, "Wet Chemical Extinguishing Systems."

H. Ground equipment.

I. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4. FIELD QUALITY CONTROL

A. Testing: See Division 23 Section, "Testing, Adjusting and Balancing."

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

1. Test each equipment item for proper operation. Repair or replace equipment that is defective, including units that operate below required capacity or that operate with excessive noise or vibration.

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

3. Test motors and rotating equipment for proper rotation and lubricate moving parts according to manufacturer's written instructions.

4. Test liquid-carrying and water and drain, and gas components for leaks. Repair or replace leaking components.

C. Remove malfunctioning units, replace with new units, and retest as specified above.

3.5. ADJUSTING

A. Set initial temperatures, and calibrate sensors.

B. Set field-adjustable switches.

3.6. CLEANING

A. Remove protective coverings and clean and sanitize hoods and associated services, both inside and out, according to manufacturer's written instructions.

B. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

3.7. DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hoods.

END OF SECTION 233813

SECTION 234100 – PARTICULATE AIR FILTRATION – STANDARD EFFICIENCY

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes standard efficiency pleated panel filters; bulk filter media; filter frames and housings; and filter gages.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

1.3. QUALITY ASSURANCE

A. Comply with ASHRAE 52.1 for arrestance and ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.

B. Comply with NFPA 90A and NFPA 90B.

1.4. EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Provide two (2) complete set(s) of filters for each filter bank.

PART 2 - PRODUCTS

2.1. GENERAL REQUIREMENTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Airguard

2. American Air Filter (AAF) / Flanders

3. Camfil (Farr)

B. Filter Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks. Frames shall provide an airtight fit with the enclosing ductwork. All joints between filter segments and enclosing ductwork shall have gaskets or seals to provide a positive seal against air leakage.

2.2. PLEATED PANEL FILTERS

A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, UL 900 Class 2, disposable air filters with holding frames. Media shall be interlaced glass or synthetic fibers coated with non-flammable adhesive. Filter-media frame shall be cardboard sealed or bonded to the media.

1. 1-inch, MERV-8 with maximum initial resistance of 0.45-inches w.g. at 500 fpm and 0.25-inches w.g. at 300 fpm.

2. 2-inch, MERV-8 with maximum initial resistance of 0.25-inches w.g. at 500 fpm and 0.15-inches w.g. at 300 fpm.

3. 2-inch, MERV-13 with maximum initial resistance of 0.30-inches w.g. at 500 fpm and 0.16-inches w.g. at 300 fpm.

2.3. BULK MEDIA

A. Description: Commercial-grade air-filter synthetic media, UL 900 Class 2, factory rolled for temporary uses during construction outside unit filter frames.

1. 1-inch, MERV-6 with maximum initial resistance of 0.25-inches w.g. at 500 fpm.

2.4. FILTER GAGES

A. Description: Diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

B. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale and logarithmic-curve tube gage with integral leveling gage, graduated to read from 0 to 2.0-inches w.g. and accurate within 3 percent of the full-scale range.

C. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

PART 3 - EXECUTION

3.1. INSTALLATION

A. Install filters in position to prevent passage of unfiltered air.

B. Install filter gage for each filter bank.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

D. Coordinate filter installations with duct and air-handling-unit installations.

3.2. CLEANING

A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

3.3. FILTER LIST

A. Mechanical Contractor shall submit, upon final walk-through, a summary of all HVAC equipment indicating filter size and number of filters. The Filter List shall also be included in the Operation and Maintenance Manual.

1. Example:

   WAYNE COUNTY SCHOOLS

   SCHOOL NAME: ROSEWOOD MIDDLE SCHOOL

MECH. ROOM #:	FILTER SIZE:
AIR HANDLER #:	QUANTITY:
MECH. ROOM #:	FILTER SIZE:
AIR HANDLER #:	QUANTITY:
MECH. ROOM #:	FILTER SIZE:
AIR HANDLER #:	QUANTITY:

END OF SECTION 234100

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SECTION 235100 – BREECHINGS, CHIMNEYS AND STACKS

PART 1 - GENERAL

1.1. SUMMARY

A. This section includes breechings, chimneys and stacks for fuel burning devices.

1.2. SUBMITTALS

A. Product Submittals: For each breeching, chimney and stack specified in this section.

1. 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.

2. Warranty: Special warranties specified in this Section.

1.3. QUALITY ASSURANCE

A. Source Limitations: Obtain listed system components through one source from a single manufacturer.

B. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

PART 2 - PRODUCTS

2.1. LISTED SPECIAL GAS VENTS, STAINLESS STEEL

A. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F continuously, with positive or negative flue pressure complying with NFPA 211.

B. Construction: ASTM A 959, Type 29-4C stainless steel inner shell and aluminized steel outer jacket separated by at least 1/2-inch airspace.

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

1. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.

PART 3 - EXECUTION

3.1. EXAMINATION

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.

3.2. APPLICATION

A. Listed Special Gas Vent: Condensing gas appliances.

3.3. INSTALLATION OF LISTED VENTS AND CHIMNEYS

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

B. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

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

D. For appliances that are 83 percent or more efficient, 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. Connect base section to foundation using anchor lugs of size and number recommended by manufacturer.

G. Join sections with acid-resistant joint cement to provide continuous joint and smooth interior finish.

H. Erect stacks plumb to finished tolerance of no more than 1 inch out of plumb from top to bottom.

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 235100

SECTION 235216 – CONDENSING BOILERS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes gas-fired condensing boilers, trim, and accessories for generating heating hot water.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for boilers.

2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

3. Shop Drawings: For boilers, boiler trim, and accessories.

a. Include plans, elevations, sections, and mounting details.

b. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

c. Include diagrams for power, signal, and control wiring.

4. Warranty: Provide sample of manufacturer's warranty.

B. Construction Submittals:

1. Manufacturer Start-Up Certification: Provide manufacturer's complete start-up procedure including verification and results of each step with dated signatures of the manufacturer's technician who performed the work and the installing contractor's supervisor who witnessed the work. The start-up procedure shall include an inspection to verify it meets the manufacturer's installation requirements.

2. Commissioning Agent Certification: Provide owner's commissioning agent's certification that boiler is installed and operating as intended.

C. Close-Out Submittals:

1. Operation and Maintenance Manuals: Provide operation and maintenance information for standard and emergency operation to be included in the Operation and Maintenance Manuals.

1.3. QUALITY ASSURANCE

A. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.

B. Efficiencies shall comply with the State Energy Conservation Code.

C. Boilers shall comply with UL-795. They shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

D. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

E. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

F. Boilers and their installation shall comply with the State Mechanical, Fuel Gas and Fire Codes.

G. Boilers with fuel input ratings up to 12,500 MBH shall comply with ASME CSD-1 and with ratings over 12,500 MBH shall comply with NFPA 85.

H. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

1.4. WARRANTY

A. Manufacturer's Warranty: Provide manufacturer’s warranty to repair or replace components of the boilers that fail in materials or workmanship within specified warranty period. Warranty period shall start at the date of Owner Acceptance. Warranty repairs and replacements shall include all parts and labor.

1. Heat Exchanger: 10-years

2. Control Board: 5 years

3. All Other Components: Whichever is greater, 1 year from startup or 18 months from shipment after Owner Acceptance.

PART 2 - PRODUCTS

2.1. CONDENSING BOILERS

A. Manufacturers: Provide full-condensing stainless steel fire-tube boilers that comply with the construction documents and are manufactured by one of the following:

1. Cleaver Brooks (ClearFire CE series)

2. Laars (MagnaTherm FT series)

3. Lochinvar (Crest series)

4. Weil-McLain (SVF Series 2)

B. Description: Factory-fabricated, -assembled, and -tested, gas-fired condensing-style water heating boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls.

C. Heat Exchanger: Fire-tube style heat exchanger designed for condensed flue gas shall be constructed of stainless steel.

D. Burner: Natural gas, forced-draft burner with 20 to 100 percent minimum firing rate modulation.

E. Blower: Centrifugal fan to operate during each burner firing sequence.

F. Gas Train: Combination gas valve with manual shutoff and pressure regulator.

1. Provide additional external gas pressure regulator if needed to provide the most reliable and stable boiler operation based on manufacturer recommendations. Coordinate boiler with service gas pressure. Gas regulators shall be vented to a safe location exterior to the building. Ventless regulators with vent limiters are not acceptable.

G. Ignition: Silicon carbide hot-surface ignition that includes flame safety supervision and 100 percent main-valve shutoff.

H. Casing:

1. Jacket: Sheet metal, with snap-in or interlocking closures.

2. Control Compartment Enclosures: NEMA 250, Type 1A.

3. Finish: Textured epoxy.

4. Insulation: Minimum 1-inch thick, mineral-fiber insulation surrounding the heat exchanger.

5. Combustion-Air Connections: Inlet and vent duct collars.

I. Thermal Efficiency at AHRI Conditions: 96% (minimum).

2.2. TRIM

A. Include devices sized to comply with ASME B31.9.

B. Safety Relief Valve: ASME rated.

C. Pressure and Temperature Gage: Minimum 3-1/2-inch diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.

D. Boiler Air Vent: Automatic.

E. Drain Valve: Minimum 3/4-inch hose-end gate valve.

F. Circulation Pump: Refer to Equipment Schedules and Section 232123 for pump requirements.

2.3. CONTROLS

A. Boiler factory-installed operating controls shall include the following features:

1. Control transformer.

2. Set-Point Input (adjustable).

3. Enable / Disable Input.

4. Status and Alarm Outputs.

B. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

1. High Cutoff: Automatic reset stops burner if operating conditions rise above maximum boiler design temperature.

2. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be automatic-reset type.

3. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.

C. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms. Communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

1. BACnet per ASHRAE 135 communication interface with the BAS shall enable the BAS operator to remotely control and monitor the boiler from an operator workstation. All control features and monitoring points displayed locally at boiler control panel shall be available through the BAS.

2.4. ELECTRICAL POWER

A. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

2.5. VENTING

A. Combustion-Gas Vent: Provide complete system, ASTM A 959, Type 29-4C stainless steel pipe with vent terminal that is listed for use with the boiler for the project's application. Provide connection thimble, indoor plate, vent adapter, condensate trap and neutralization tank, and sealant.

B. Combustion-Air Intake: Provide complete system, stainless steel, CPVC, or Polypropylene pipe with vent terminal that is listed for use with the boiler for the project's application. Provide with screen, inlet air coupling, and sealant.

2.6. SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.

PART 3 - EXECUTION

3.1. EXAMINATION

A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance of the Work.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

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

3.2. BOILER INSTALLATION

A. Equipment Mounting: Install boilers on 4-inch tall light-weight cast-in-place concrete equipment base(s).

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

3.3. CONNECTIONS

A. Install piping adjacent to boiler to allow service and maintenance.

B. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

C. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service.

D. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas-train connection. Provide a reducer if required.

E. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

F. Install piping from safety relief valves to nearest floor drain.

G. Install flue venting and combustion-air intake.

H. Ground equipment consistent with the requirements of Division 26.

I. Connect wiring consistent with the requirements of Division 26.

3.4. FIELD QUALITY CONTROL

A. Manufacturer Inspection and Start-Up: A Factory-authorized and trained service representative shall test and inspect equipment, components, assemblies and their installations including connections. The representative shall perform the following tests and inspections:

1. Perform installation and startup checks according to manufacturer's written instructions.

2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.

3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.

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

a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.

b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

B. Boiler will be considered defective if it does not pass tests and inspections.

C. Provide test and inspection reports within 30 days of completion and manufacturer approval.

D. Occupancy Adjustments: Upon request within 1 year from the date of owner accepted completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to four (4) owner requested visits to project site for this purpose.

3.5. DEMONSTRATION

A. Engage a factory-authorized service representative to train owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section 230200 for demonstration and training requirements.

END OF SECTION 235216

SECTION 236426 – AIR-COOLED CHILLERS
(EQUIPMENT FURNISHED UNDER SEPARATE CONTRACT)

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes packaged, air-cooled, electric motor driven chillers.

B. Chillers furnished under separate contract for installation under this contract. Mechanical contractor shall obtain final pre-purchase equipment submittal for equipment and accessories furnished under separate contract for installation under this contract. All required equipment, accessories, services, and warranties not furnished under said separate contract shall be provided by the mechanical contractor under this contract.

1.2. SUBMITTALS

A. Product Submittals:

1. Product Data: For each type of product indicated include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.

a. Performance at ARI standard conditions and at conditions indicated.

b. Performance at ARI standard unloading conditions.

c. Minimum evaporator flow rate.

d. Refrigerant capacity of chiller.

e. Oil capacity of chiller.

f. Fluid capacity of evaporator.

g. Characteristics of safety relief valves.

h. Minimum entering condenser-air temperature.

i. Maximum entering condenser-air temperature.

j. Performance at varying capacities with constant-design entering condenser-air temperature. Repeat performance at varying capacities for different entering condenser-air temperatures from design to minimum in 5 deg F increments.

k. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

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l. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, method of field assembly, components, and location and size of each field connection.

m. Wiring Diagrams: For power, signal, and control wiring.

2. Warranty: Sample of special warranty.

B. Close-Out Submittals:

1. Operation and Maintenance Data: For each chiller to include in emergency, operation, and maintenance manuals.

1.3. EXTRA MATERIALS

A. Extra Stock: Provide owner with the following extra materials:

1. Quart container of paint used in application of topcoat to use in touchup applications.

1.4. QUALITY ASSURANCE

A. ARI Certification: Certify chiller according to AHRI 590 certification program(s).

B. ASME Compliance: Fabricate and label chiller to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and include an ASME U-stamp and nameplate certifying compliance.

C. Efficiencies shall comply with the State Energy Conservation Code.

D. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

E. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

F. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

1.5. DELIVERY, STORAGE, AND HANDLING

A. Ship each chiller with a full charge of refrigerant. Charge each chiller with nitrogen if refrigerant is shipped in containers separate from chiller.

B. Ship each oil-lubricated chiller with a full charge of oil.

1.6. COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.7. WARRANTY

A. Special Warranty: Manufacturer's complete machine parts, labor and refrigerant warranty for 5-years from the date of Owner Acceptance.

PART 2 - PRODUCTS

2.1. GENERAL REQUIREMENTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following for scroll-type compressor chillers:

1. Carrier (30R Series)
2. Daikin-McQuay (AGZ Series)
3. Trane (CGAM Series)

2.2. PACKAGED, AIR-COOLED CHILLERS

A. Description: Factory-assembled and run-tested chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.

B. Cabinet: Chiller cabinet shall be manufacturer's standard galvanized steel construction with corrosion protection coating and exterior finish.

1. Architectural Louvered Panels: Provide unit with louvered panels that completely cover the condenser coils and service areas beneath the condenser coils.

C. Enhanced Sound-Reduction: Factory provided and field installed package designed to reduce sound level without affecting performance, including an added acoustic enclosure around compressors, reducing fan speeds and acoustically treating fans.

2.3. CHILLERS WITH SCROLL COMPRESSORS

A. Compressors: Positive displacement, direct-drive, semi-hermetic compressors with precision-machined cast-iron casing and manufacturer's standard scroll design. Each compressor shall be equipped with suction and discharge shut-off valves, crankcase oil heater and suction strainer.

1. Capacity Control: On-off compressor cycling with hot-gas bypass or digital compressor unloading.

2. Oil Lubrication System: Consisting of automatic pump with strainer, sight-glass, filling connection, filter with magnetic plug, and initial oil charge.

3. Compressor Motors: High-torque, two-pole induction type motors with inherent thermal-overload protection on each phase and hermetically sealed and cooled by refrigerant suction gas.

4. Compressor Motor Controllers: Across-the-Line NEMA ICS 2, Class A, full-voltage, non-reversing."

B. Refrigerant Circuits:

1. Refrigerant: R-454B or R-32

2. Refrigerant Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

3. Refrigerant Circuit: Each shall include a thermal- or electronic-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.

4. Pressure Relief Valves: ASME-rated, spring-loaded, multi-reseating type pressure relief valves shall be provided for each heat exchanger. Comply with ASHRAE 15, ASHRAE 147 and applicable portions of ASME Boiler and Pressure Vessel Code.

C. Evaporator: Brazed-plate or shell-and-tube design, as indicated.

1. Shell and Tube Type: Direct-expansion, shell-and-tube design, tested and stamped according to ASME Boiler and Pressure Vessel Code.

a. Shell Material: Carbon steel.

b. Shell Heads: Removable carbon-steel heads with multi-pass baffles designed to ensure positive oil return and located at each end of the tube bundle.

c. Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.

d. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.

2. Brazed Plate Type: Direct-expansion, single-pass, brazed-plate design, tested according to ASME Boiler and Pressure Vessel Code.

a. Plate Material: Type 304 or 316 stainless-steel construction.

b. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.

c. Inlet Strainer: Factory-furnished, 40-mesh strainer for field installation in supply piping to evaporator.

3. Flow Switch: Factory furnished and field installed, thermal-type flow switch wired to chiller operating controls.

4. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F.

D. Air-Cooled Condenser:

1. Coil(s) with integral sub-cooling on each circuit.

2. Copper Tube with Plate Fin Coils: Coils constructed of copper tubes mechanically bonded to aluminum fins.

3. Aluminum Microchannel Coils: Coils constructed of a series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds. Fins, tubes, and header manifolds shall be constructed of aluminum alloy treated with a corrosion-resistant coating.

4. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

5. Fans and Fan Motors: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge. Refer to Sections 230513 and 233416.

6. Fan Guards: Removable steel safety guards with corrosion-resistant coating.

E. Electrical Power: Factory installed and wired switches, motor controllers, transformers, and other electrical devices necessary to provide a single-point field power connection. Wiring shall be numbered and color-coded to match wiring diagram. Electrical equipment shall be mounted in a NEMA 250, Type 3R enclosure with hinged access door, lock and key. Factory installed wiring located outside the enclosure shall be routed in metallic raceway with no more than 24-inch length of liquid-tight or flexible metallic conduit at connections.

1. Field power interface shall be to NEMA 1, heavy-duty, non-fused disconnect switch. Minimum SCCR according to UL 508 shall be as required by electrical power distribution system, but not less than 65,000A.

2. Each motor shall have branch power circuit and controls with fused disconnect switch or circuit breaker disconnecting means with SCCR to match main disconnecting means: Each motor shall have overcurrent protection. Overload relay shall be sized according to UL 1995 or be an integral component of water chiller control microprocessor.

3. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.

4. Power Factor Correction: Capacitors to correct power factor to 0.95 at full load.

5. Controls Power: Provide unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity and auxiliary and adjustable time-delay relays or an integral to water chiller microprocessor.

6. User Interface: Indicate the following for water chiller electrical power supply:

a. Current, phase to phase, for all three phases.

b. Voltage, phase to phase and phase to neutral for all three phases.

c. Three-phase real power (kilowatts).

d. Three-phase reactive power (kilovolt amperes reactive).

e. Power factor.

f. Running log of total power versus time (kilowatt hours).

g. Fault log, with time and date of each.

F. Controls: Factory installed, wired, and functionally tested standalone, microprocessor based controls with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power. Controls shall share enclosure with electrical power devices or provide a separate enclosure of matching construction.

1. Operator Interface: Keypad or pressure-sensitive touch screen with multiple-character digital display. Display the following:

a. Date and time.

b. Operating or alarm status.

c. Operating hours.

d. Outside-air temperature if required for chilled-water reset.

e. Temperature and pressure of operating set points.

f. Chilled-water entering and leaving temperatures.

g. Refrigerant pressures in evaporator and condenser.

h. Saturation temperature in evaporator and condenser.

i. No cooling load condition.

j. Elapsed time meter (compressor run status).

k. Pump status.

l. Anti-recycling timer status.

m. Percent of maximum motor amperage.

n. Current-limit set point.

o. Number of compressor starts.

p. Alarm history with retention of operational data before unit shutdown.

q. Superheat.

2. Control Functions:

a. Manual or automatic startup and shutdown time schedule.

b. Capacity control based on evaporator leaving-fluid temperature.

c. Capacity control compensated by rate of change of evaporator entering-fluid temperature.

d. Chilled-water entering and leaving temperatures, control set points, and motor load limit.

e. Current limit and demand limit.

f. External water chiller emergency stop.

g. Anti-recycling timer.

h. Automatic lead-lag switching.

3. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:

a. Low evaporator pressure or high condenser pressure.

b. Low chilled-water temperature.

c. Refrigerant high pressure.

d. High or low oil pressure.

e. High oil temperature.

f. Loss of chilled-water flow.

g. Control device failure.

4. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.

a. BACnet per ASHRAE 135 communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. All control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.

b. Hardwired I/O Points:

1) Monitoring: On/off status, common trouble alarm, electrical power demand, and electrical power consumption.

2) Control: On/off operation, chilled-water discharge temperature set-point adjustment, and electrical power demand limit.

5. Factory-installed wiring outside of enclosures shall be in NFPA 70-complaint raceway. Make terminal connections with liquid-tight or flexible metallic conduit.

G. Insulation: Closed-cell, flexible, elastomeric thermal insulation complying with ASTM C 534/C 534M, Type I for tubular materials and Type II for sheet materials. Factory-apply insulation over all cold surfaces of chiller capable of forming condensation. Components shall include evaporator, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.

1. Thickness: 3/4-inch, minimum.

2. Paint: After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.

2.4. SOUND REDUCTION FEATURES

A. Sound Reduction Features: Provide factory installed or factory-fabricated and field installed accessories from the chiller manufacturer designed to reduce noise from the standard product.

1. Compressor Muffler
2. Low Noise Condenser Fans
3. Refrigerant Piping Sound Absorption Insulation
4. Refrigerant Piping Metallic Flexible Connections
5. Condenser Fan Speed Control

2.5. SOURCE QUALITY CONTROL

A. Perform functional tests of chillers before shipping.

B. Factory run test each air-cooled chiller with water flowing through evaporator.

C. Factory test and inspect evaporator and condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. For chillers located outdoors, rate sound power level according to ARI 370.

PART 3 - EXECUTION

3.1. EXAMINATION

A. Examine chillers before installation. Reject chillers that are damaged.

B. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.

1. Final chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

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

3.2. CHILLER INSTALLATION

A. Equipment Mounting:

1. Install chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations.

2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548.

B. Maintain manufacturer's recommended clearances for service and maintenance.

C. Charge chiller with refrigerant and fill with oil if not factory installed.

D. Install separate devices furnished by manufacturer and not factory installed.

3.3. CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 and 232116. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to chiller to allow service and maintenance.

C. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, and drain connection with valve. Make connections to chiller with a flange.

3.4. STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Verify that refrigerant charge is sufficient and chiller has been leak tested.

3. Verify that pumps are installed and functional.

4. Verify that thermometers and gages are installed.

5. Operate chiller for run-in period.

6. Check bearing lubrication and oil levels.

7. For chillers installed indoors, verify that refrigerant pressure relief device is vented outdoors.

8. Verify proper motor rotation.

9. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.

10. Verify and record performance of fluid flow and low-temperature interlocks for evaporator.

11. Verify and record performance of chiller protection devices.

12. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.

C. Prepare test and inspection startup reports.

3.5. DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chillers.

END OF SECTION 236426

SECTION 237200 – AIR-TO-AIR ENERGY RECOVERY EQUIPMENT (EQUIPMENT FURNISHED UNDER SEPARATE CONTRACT)

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes air-to-air, total energy fixed-membrane heat exchangers.

B. Energy recovery units furnished, integral with air handling units under separate contract for installation under this contract. Mechanical contractor shall obtain final pre-purchase equipment submittal for equipment and accessories furnished under separate contract for installation under this contract. All required equipment, accessories, services, and warranties not furnished under said separate contract shall be provided by the mechanical contractor under this contract.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

2. Shop Drawings: For air-to-air energy recovery equipment. Include plans, elevations, sections, details, and attachments to other work.

B. Close-Out Submittals:

1. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

1.3. MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set of each type of filter specified.

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1.4. QUALITY ASSURANCE

A. AHRI Compliance: Capacity ratings for air-to-air energy recovery equipment shall comply with AHRI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment." Capacity ratings for air coils shall comply with AHRI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils."

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup." Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Ex-changers."

C. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

D. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

E. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

1.5. WARRANTY

A. Warranty: Manufacturer agrees to replace components of units that fail in materials or workmanship within specified warranty period.

1. Total Energy Fixed-Plate Heat Exchangers: 10 years from date of Owner Acceptance.

PART 2 - PRODUCTS

2.1. GENERAL REQUIREMENTS

A. Manufacturers: Subject to compliance with requirements, provide fixed-plate total energy exchangers by the following:

1. Daikin McQuay
2. RenewAire
3. Venmar CES / Nortek Air Solutions
4. Manufacturer of air handling or packaged unit with standard factory-installed energy recovery equipment

B. Refer to mechanical detail drawings for general arrangement elevation views of air handling units with energy recovery.

C. Refer to mechanical equipment schedules for additional energy recovery information.

2.2. FIXED-PLATE TOTAL ENERGY EXCHANGERS

A. Description: Factory-fabricated fixed-plate cross-flow air-to-air sensible and latent heat exchangers without moving parts. The heat exchanger shall be able to withstand a 5-inch w.g. pressure differential.

1. Frost Prevention: Exchangers shall not condense or frost at outside air temperatures above (-)10 deg F and exhaust air relative humidity below 40 percent. Supplemental defrost elements, such as electric resistance heat, is not acceptable.

B. Casing: Casing materials shall match that of the air handling or packaged unit the exchanger is installed.

1. Access Doors: Comply with the requirements of Section 237316.

C. Plates: Evenly spaced and sealed and arranged for counter airflow such that supply and exhaust air streams shall never mix.

1. Plate Material: Chemically treated paper or polymer with selective hydroscopicity and moisture permeability, and gas barrier properties.

D. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.

E. Filters: Comply with requirements of Section 234100.

PART 3 - EXECUTION

3.1. INSTALLATION

A. Fixed-Plate Exchangers: Install heat exchangers so supply and exhaust airstreams flow in opposite directions.

1. Install access doors in both supply and exhaust airstreams, both upstream and downstream, for access to heat exchanger. Access doors and panels shall comply with the requirements of Section 237316.

B. Install units with clearances for service and maintenance.

C. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

D. Pipe drains from drain pans to nearest floor drain; use ASTM B 88, Type L, drawn-temper copper water tubing with soldered joints, same size as condensate drain connection.

E. Install motorized isolation dampers at outside air inlet and exhaust air outlet from heat exchanger. Where manufacturer does not offer integral isolation dampers, field-installed motorized isolation dampers shall be provided at the outside air and exhaust air ductwork connections to the air handling unit casing. Dampers shall be interlocked to open when the respective fan is operating.

3.2. CONNECTIONS

A. Comply with requirements for piping specified in Sections 232113 and 232116. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to unit to allow service and maintenance.

C. Connect piping to units mounted on vibration isolators with flexible connectors.

D. Connect cooling condensate drain pans with air seal trap at connection to drain pan and install cleanouts at changes in pipe direction.

E. Comply with requirements for ductwork specified in Section 233113.

F. Install electrical devices furnished with units but not factory mounted.

3.3. FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

2. Adjust seals and purge.

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

4. Set initial temperature and humidity set points.

5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

6. Prepare test and inspection reports.

3.4. DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy recovery equipment.

END OF SECTION 237200

SECTION 237311 – BLOWER COIL UNITS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes packaged indoor heating-only blower coil units.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1. Product Data: For each unit indicated, provide unit dimensions and weight; cabinet material, metal thickness, insulation, and accessories; certified fan-performance curves with system operating conditions indicated; motor ratings, electrical characteristics, and certified coil-performance ratings with system operating conditions indicated; dampers; and filters with performance characteristics.

B. Close-Out Submittals:

1. Operation and Maintenance Data: For units to include operation and maintenance manuals, including maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

1.3. QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

B. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

C. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

1.4. COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

C. Coordinate location of piping and electrical rough-ins.

1.5. WARRANTY

A. Warranty: Parts and labor warranty of 1 year for the entire unit from the date of Owner Acceptance.

1.6. EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: Two set(s) for each blower coil unit.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Daikin Applied (BCV/BCA/BCH)

2. Enviro-Tec (H/V/VB/VR series)

3. Greenheck (LFC/VFC series)

4. Titus (TB series)

5. Trane Company (BC series)

2.2. HORIZONTAL AND VERTICAL BLOWER COIL UNITS

A. Blower Coil Unit Configurations: Provide vertical and horizontal unit configurations as indicated in the documents.

B. Factory-packaged and tested units rated according to AHRI 440, ASHRAE 33 and UL 1995.

C. Casing Fabrication: Factory-fabricated and constructed wall, roof and floor single-wall 18-gauge galvanized steel casing panels with 1-inch (R-4) insulation, board or coated glass fiber with foil-face, and formed galvanized steel channel framing. No through-metal casing thermal breaks. All joints shall be water-resistant sealed. Casing shall meet ASHRAE 111 with less than 2.0% leakage at 1.0-inches w.g. pressure. Unit shall have removable access panels to maintain all components.

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.

D. Fan and Motor: Removable fan and motor board. Motors shall be permanently-lubricated, multispeed; resiliently mounted on motor board that comply with Section 230513. Connect motor to chassis wiring with plug connection.

1. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

E. Heating Coils: Provide units with coil types indicated in the documents.

1. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

F. Filters: 2-inch, MERV-13 complying with Section 234100.

G. Electrical Connection: Factory wired motors and controls for a single point electrical connection. Electrical components shall comply with NFPA 70 and Division 26.

H. DDC Controls: Controls shall be field installed by the building automation system (BAS) installer. Refer to Sequences of Operation and Section 230900 for requirements.

I. Packaged Electronic Controls: Factory-installed pre-programmed unit-mounted controls with 24V control-voltage transformer, data entry and access point and volatile-memory backup. Input data includes room temperature, and humidity set points and occupied and unoccupied periods. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status. Controls shall modulate heating coil capacities, start/stop fan, open/close return and outside air dampers, monitor space temperatures and humidity, and maintain occupied/unoccupied schedules.

1. Automatic Control: Microprocessor-type wall-mounted electronic thermostat with digital display that uses proportional integral (PI) algorithms for precise control. Thermostat shall have automatic heat-ventilate changeover; fan on-auto selection; high-medium-low fan speed selection; adjustable deadband; exposed space and set point temperatures and humidity; occupied/unoccupied schedule; and unoccupied-period override push button.

    a. Building Automation System (BAS) Interface Requirements: Provide BACnet interface between packaged controls and the BAS. The interface shall include fan start/stop, fan speed, fan failure alarm, heating and ventilating status, damper open/close, temperature and

humidity set points and deadbands. Refer to control sequences of operation and Section 230900 for further requirements.

PART 3 - EXECUTION

3.1. EXAMINATION

A. Examine roughing-in for piping and electrical connections to verify actual locations before blower coil unit installation.

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

3.2. INSTALLATION

A. Install blower coil units level and plumb.

B. Install blower coil units to comply with NFPA 90A.

C. Install vertical-upflow blower coil units on raised welded-steel support frame for bottom return air duct connection.

D. Verify locations of thermostats, humidistats, and other exposed control sensors with drawings and room details before installation. Install devices 48-inches above finished floor.

E. Install new filters in each blower coil unit within two weeks after Substantial Completion.

3.3. CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.

2. Connect piping to blower coil unit. Install valve kits and isolation valves in piping as indicated.

B. Connect supply-air and return-air ducts to blower coil units with flexible duct connectors specified in Section 233300.

C. Ground and connect equipment according to comply with NFPA 70 and Division 26.

3.4. FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.5. ADJUSTING

A. Adjust initial temperature and humidity set points.

3.6. DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain blower coil units.

END OF SECTION 237311

SECTION 237316 – MODULAR AIR HANDLING UNITS
(EQUIPMENT FURNISHED UNDER SEPARATE CONTRACT)

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes modular indoor and outdoor central-station air handling units.

B. Air handling units furnished under separate contract for installation under this contract. Mechanical contractor shall obtain final pre-purchase equipment submittal for equipment and accessories furnished under separate contract for installation under this contract. All required equipment, accessories, services, and warranties not furnished under said separate contract shall be provided by the mechanical contractor under this contract.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1. Product Data: For each air-handling unit indicated, provide unit dimensions and weight; cabinet material, metal thickness, finishes, insulation, and accessories; certified fan-performance curves with system operating conditions indicated; certified fan-sound power ratings; fan construction and accessories; motor ratings, electrical characteristics, and motor accessories; certified coil-performance ratings with system operating conditions indicated; dampers including housings, linkages, and operators; and filters with performance characteristics.

2. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved: mechanical-room layout and relationships between components and adjacent structural and mechanical elements; support location, type, and weight; and field measurements.

B. Close-Out Submittals:

1. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.3. QUALITY ASSURANCE

A. Applicable components of the air handling units shall comply with:

1. Fan Sound-Power Level Ratings: Comply with AMCA 300 and 301. Fans shall bear AMCA-certified sound ratings seal.

2. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210.

3. Water Coils: Factory tested to 300 psig according to AHRI 410 and ASHRAE 33.

4. NFPA 70 (National Electric Code) and 90A

5. AMCA 204, 205, 211 and 311

6. AHRI 260, 261, 430 and 1060

7. ASHRAE 62.1, Section 5 and 7

8. ASHRAE/IESNA 90.1, Section 6

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Indoors: Flame-spread index of 25 or less and smoke-developed index of 50 or less.

2. Outdoors: Flame-spread index of 75 or less and smoke-developed index of 150 or less.

C. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

D. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

E. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

1.4. COORDINATION

A. Coordinate sizes, weights (operational and shipping) and locations of supports and opening with the actual equipment provided, including:

1. Concrete bases

2. Structural steel support members

3. Roof curbs

4. Roof/floor openings

1.5. EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: Two set(s) for each air-handling unit.

2. Gaskets: One set for each access door.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide product by one of the following:

1. Carrier (39M indoor/outdoor series).

2. Daikin/McQuay (Vision indoor / Skyline outdoor series).

3. Trane Company (Performance Climate Changer indoor/outdoor series).

2.2. GENERAL REQUIREMENTS

A. Refer to mechanical detail drawings for general arrangement elevation views of each air handling unit.

2.3. UNIT CASINGS

A. Casing Fabrication: Factory-fabricated and constructed wall, roof and floor double-wall panels with 2-inch (R-13) closed-cell injected-foam or board insulation within formed galvanized steel channel framing. Provide stainless steel interior liner at all sections. Units shall be thermally broken to minimize the conduction path from the inside of the casing to the outside. All joints shall be air-tight and water-resistant sealed.

1. Casing Performance:

a. Leakage: Casing shall meet AHRI 1350 Casing Air Leakage Rate CL3 with less than 10 cfm leakage per 100 sqft. at 6.0-inches w.g. positive or negative internal pressure.

b. Deflection: Casing shall meet AHRI 1350 Casing Deflection Rate CD3 with less than 0.0042-inches (1/240) deflection per inch of span at 6.0-inches positive or negative internal pressure. Floor deflection shall not exceed 0.0625-inches at 6-inches internal pressure and 300-pound per sqft. live load.

2. Casing Materials: 18-gauge G90 galvanized steel exterior;18-gauge stainless steel interior; and 18-gauge perforated stainless steel interior at fan sections.

3. Casing Finish: Factory-applied prime-coat and thermosetting top-coat baked-on enamel.

4. Casing Section Gaskets: Neoprene gasket around entire perimeter of casing section joints.

B. Floor: Walking surfaces of floor panels shall have a solid 3/16-inch thick checker-plate aluminum solid lining with water-tight welded seams and reinforcements to support 300-pound per sqft. live load

1. Floor Openings: Floor openings shall be covered with removable aluminum or stainless steel grating to support 300-pound per sqft. live load.

C. Roof: The roof of outdoor units shall be pitched at a minimum 1/2-inch to 12-inch slope to one side of the unit.

D. Access Doors and Panels: Factory-fabricated double wall, to match casing and insulation materials, finish and performance and suitable for unit pressure and leakage classification. Doors shall open against positive pressure and be large enough to remove associated components such as motors, filters, etc. but no smaller than 24-inches wide and 60-inches tall. Additional access panels shall be provided to aid in removal of components such as fans, coils, etc.

1. Door Hinges, Latches and Handles: Minimum of two ball-bearing or piano hinges, two wedge-lever latches and steel quarter-turn handles.

2. Door Gaskets: Neoprene gasket around entire perimeter of door frames.

3. View Panels: In units sized for 10,000 CFM or more, provide 12-inch x 12-inch, double-glazed, wired-glass with an air space and rubber perimeter seals. View panels shall be located on the accessible side of the air handler in each fan section and coil access section doors.

E. Condensate Drain Pans: Factory-fabricated, insulated stainless steel, water-tight sealed, minimum 2-inches deep drain pans sloped minimum 2-percent in two directions to comply with ASHRAE 62.1 and

to collect condensate from cooling coils (including coil piping connections, coil headers and return bends) and humidifiers and direct water toward drain connection. Pan shall extend downstream of coil face to comply with ASHRAE 62.1. Drain connection shall be on the bottom side and at the lowest point on the pan. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

F. Base Rails: Structural steel channel rails continuous at the unit's perimeter and at intermediate locations needed to support internal components suitable for mounting on structural steel platform or concrete pad. Base rails be galvanized steel construction and outdoor unit base rails shall have an epoxy-based paint finish.

G. Lifting and Handling Provisions: Factory-installed shipping skids and lifting lugs.

H. Outdoor Unit Roof Curbs: Factory-fabricated, insulated, full-perimeter curb of sheet metal, minimum 14-inches high, with neoprene sealing strip, and welded Z-bar flashing. Fully insulate the internal perimeter of the curb with 2-inches (R-10) of polyisocyanurate board insulation. Insulation shall be mechanically fastened to the sheet metal. Comply with requirements in "The NRCA Roofing Manual."

I. Intake and Discharge Hoods: Factory-fabricated, galvanized steel intake and discharge weather hoods with bird screen and finish to match unit casing.

2.4. FAN, DRIVE AND MOTOR SECTION

A. Fans: Comply with requirements of Section 233400.

B. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower. Shafts shall be designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.

C. Fan Housings:

1. Plenum Fan Housings: Direct-drive centrifugal type, steel frame and panel, fabricated without fan scroll and volute housing.

D. Fan Wheels:

1. Centrifugal Plenum Fan Wheels: Airfoil wheels shall be single-width single-inlet (SWSI) construction with heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

E. Fan Arrays: Direct-drive modular-plenum fans in a parallel array, using number of fans indicated but not less than 3, arranged to provide equal air flow across the unit's cross-section. The fans in each array shall be identical.

1. Fan Vibration Isolation: Each fan shall be factory-mounted with neoprene pads.

2. Fan Enclosures: Enclosure walls shall be constructed to reduce fan noise by minimum 6 dBA based on AMCA 301 ratings.

3. Backdraft Dampers: Each fan shall have a factory-mounted motor-operated low-leakage backdraft damper that complies with the requirements of Section 233300. Pressure losses across the dampers shall be included in the fan performance data and not considered to be included in the unit's scheduled pressure drop.

4. Variable Speed Drives: Comply with the requirements of Section 230514. Drives manufactured by the air handling unit manufacturer are also acceptable in addition to the manufacturers listed in Section 230514.

5. Over-Speeding: Variable frequency drives shall not be set above 60 Hz.

a. Exceptions:

1) Air Handling Units with Setback Schedules: Variable frequency drives shall not operate over 85 Hz and motors shall not operate over 3,000 RPM for direct-drive fans used in air handling units.

6. Air Flow Measuring Stations: Differential pressure type piezometer ring mounted on the throat of the inlet cone. Accuracy shall be plus or minus 5 percent, including transducer and conversion error, at 100 to 5,000 fpm.

F. Fan Shaft Bearings:

1. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings, L10 rated for 200,000 hours with adapter mount and two-piece, cast-iron housing with grease lines extended to outside unit.

G. Internal Vibration Isolation: Fans shall be factory mounted with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.

H. Motors: Comply with requirements of Section 230513.

I. Variable Frequency Controllers: Refer to Section 230514.

1. Indoor Units: Mount variable speed drives on mechanical room walls, adjacent to the air handling unit where indicated on the drawings. Variable speed drives shall not be unit mounted.

2. Outdoor Units: Mount variable speed drives within dedicated pre-manufactured casing compartment. Variable speed drives shall not be installed outdoors without supplemental cooling.

J. Motor Starters and Disconnects: Refer to Section 230511.

1. Where indicated to be unit-mounted, mount motor starters and disconnect switches on unit exterior per manufacture's recommendations.

2.5. COIL SECTION

A. Heating and Cooling Coils: Provide coil types in positions indicated. Comply with requirements of Section 238216. Coils shall comply with ARI 410.

1. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).

2. Fabricate cooling coils with stainless steel frames.

3. Coils shall not act as structural component of unit.

B. Piping Enclosure: Hydronic coils in outdoor units shall come equipped with a factory-fabricated piping enclosure. The enclosure shall be constructed to match the unit casing materials and finish; match the unit height; be installed on a roof curb that encloses the piping roof penetrations; and have minimum 24-inch tall by 12-inch wide, hinged access doors on both sides to provide maintenance access to all valves and fittings.

2.6. MAINTENANCE ACCESS SECTION

A. Maintenance Access Sections: Provide access sections as indicated in the documents; but not less than one 24-inch long section between coils unless otherwise noted. Each section shall be equipped with access doors on both sides of the unit.

2.7. AIR FILTRATION SECTION

A. Filters: Filter sections shall be designed for the indicated filter types and orientations. Where not indicated, provide housings and frames for angled 2-inch deep filters.

B. Filter Holding Frames: Provide filter holding frames arranged for flat or angled orientation, with access doors on both sides of unit. Filters shall be removable from either side.

1. Panel Filters: Factory-fabricated galvanized steel filter holding frames arranged for flat or angular orientation as indicated, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

C. Filter Gage: Provide filter gage to measure pressure loss, 0 to 2-inches w.g., across each filter bank. Mount gages on unit casing directly above filter section access doors. Dwyer “Magnehelic” or equal.

2.8. MIXING BOX SECTIONS

A. Mixing boxes shall be factory fabricated as a standard sectional component of the modular unit. Return, outdoor, and relief air dampers as specified, shall be installed in the factory fabricated mixing boxes. Damper linkages and motor operators shall be internal to the mixing box.

2.9. DAMPERS

A. Leakage Rate: At a minimum, dampers leakage shall comply with AMCA Class I. Damper leakage rate shall not exceed 2 percent of air quantity at 2000-fpm face velocity through damper and 4-inch wg pressure differential based on AMCA 500.

1. Isolation Dampers: Refer to Section 233300.

B. Damper Operators: Comply with requirements in Section 239000.

C. Electronic Damper Operators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

1. Operator Motors: NEMA Premium Efficient motor, complying with Section 230513, sized to operate with sufficient reserve power to provide smooth modulating action or two-position action. Permanent split-capacitor or shaded-pole type with gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

2. Non-spring-return motors for dampers larger than 25 sqft. shall be sized for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.

3. Spring-return motors for dampers larger than 25 sqft. shall be sized for running and breakaway torque of 150 in. x lbf.

4. Size dampers for running torque calculated as follows:

    a. Parallel-blade dampers shall have running torque based on 7 inch-lb/sqft. of damper with edge seals and 4 inch-lb/sqft. of damper without edge seals.

    b. Opposed-blade dampers shall have running torque based on 5 inch-lb/sqft. of damper with edge seals and 3 inch-lb/sqft. of damper without edge seals.

    c. Increase running torque by 1.5 when dampers are exposed to 2 to 3-inches of pressure drop or 1000 to 2500 fpm face velocities. Increase running torque by 2.0 when dampers are exposed to 3 to 4-inches of pressure drop or 2500 to 3000 fpm face velocities.

5. Coupling: V-bolt and V-shaped, toothed cradle.

6. Overload Protection: Electronic overload or digital rotation-sensing circuitry.

7. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on non-spring-return actuators.

8. Power Requirements (Two-Position Spring Return): 24 V ac.

9. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.

10. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.

11. Temperature Rating: Minus 22 to plus 122 deg F.

12. Run Time: 12 seconds open and 5 seconds closed, unless otherwise indicated.

D. Energy Recovery Face-and-Bypass Dampers: Opposed-blade, aluminum dampers with cadmium-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single aluminum frame and with operating rods connected with a common linkage. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.

E. Outdoor- and Return-Air Mixing Dampers: Aluminum dampers mechanically fastened to cadmium-plated steel operating rod in reinforced cabinet. Actuate dampers independently and simultaneously. Outdoor air dampers shall fail closed with spring return unless otherwise noted.

1. Outside Air (OA): Parallel blade type.

2. Return Air (RA): Parallel blade type.

2.10. AIR-TO-AIR ENERGY RECOVERY

A. Energy Recovery Section: Where indicated, provide energy recovery devices complying with Section 237200.

PART 3 - EXECUTION

3.1. DELIVERY

A. All air handling unit openings shall be protected during shipping and rigging with sheet metal covers. The entire unit including each shipping section shall be wrapped in 7 mils plastic shrink wrap to maintain unit cleanliness.

3.2. EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for hydronic and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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

3.3. INSTALLATION

A. Equipment Mounting:

1. Install indoor air-handling units on cast-in-place concrete equipment bases.

2. Install outdoor air-handling units on roof curbs.

3. Comply with requirements for vibration isolation and wind and seismic control devices specified in Section 230548.

B. Arrange installation of units to provide access space around air-handling units for service and maintenance. Coordinate unit locations and duct connections with structural elements such as roof trusses and floor joists.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

D. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

3.4. CONNECTIONS

A. Comply with requirements for piping specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air-handling unit to allow service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans and extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot and Chilled Water Piping: Comply with applicable requirements in Sections 232113 and 232116. Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

F. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300.

3.5. FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

C. Prepare test and inspection reports.

3.6. STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Verify that shipping, blocking, and bracing are removed.

3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.

4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.

5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.

6. Verify that energy recovery module face-and-bypass dampers provide full face flow.

7. Verify that outdoor- and return-air mixing dampers open and close and maintain minimum outdoor-air setting.

8. Comb coil fins for parallel orientation.

9. Install new, clean filters.

10. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.

2. Measure and record motor electrical values for voltage and amperage.

3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.7. ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 for air-handling system testing, adjusting, and balancing.

C. Coordinate various adjustments with the TAB Contractor including fan speed/airflow adjustments and damper operation/setpoint requirements.

3.8. CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units inside and out. Remove internal foreign materials, construction dirt, and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.9. DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 237316

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SECTION 238116 – DUCTLESS MINI-SPLIT SYSTEMS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes ductless mini-split system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Close-Out Submittals:

1. Operation and Maintenance Data: For ductless mini-split system units to include in emergency, operation, and maintenance manuals.

1.3. QUALITY ASSURANCE

A. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15.

2. Comply with applicable requirements in ASHRAE 62.1.

B. Efficiencies shall comply with the State Energy Conservation Code.

C. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

D. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

E. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

1.4. COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

B. Coordinate sizes and locations of equipment supports, and wall penetrations with actual equipment provided.

1.5. WARRANTY

A. Warranty Period: Manufacturer's complete parts, labor and refrigerant warranty for 2-years and compressor warranty for 5-years from the date of Owner Acceptance.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carrier/Toshiba
2. Daikin/McQuay
3. LG
4. Mitsubishi
5. Samsung
6. Trane

2.2. SINGLE-ZONE INDOOR UNITS

A. Concealed Evaporator-Fan Components:

1. Chassis: Impact resistant plastic casing with manually adjustable discharge air vent. Mounting and configuration type as indicated.
2. Insulation: Faced, glass-fiber duct liner.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with AHRI 206/110.
4. Fan: Forward-curved wheel directly connected to motor.
5. Fan Motor: Multi-tapped, multispeed motors with internal thermal protection and permanent lubrication that comply with Section 230513. Connect motor to chassis wiring with plug connection.
6. Filters: Minimum MERV-6, permanent, removable and cleanable.
7. Condensate Drain Pan: ABS plastic or stainless steel main drain pan with minimum 1-inch NPS drain piping connection at the pan's lowest point and fabricated to comply with ASHRAE 62.1.

a. Integral Condensate Pump: Provide units with integral condensate pumps where gravity drainage cannot be achieved.

b. Condensate Drain Pan Overflow Safety Switch: Low-voltage, float-type safety switch designed for condensate drain pan high-level alarm for unit shutdown and alarming. Switch shall shutdown unit when condensate levels in the drain pan reach the high-level mark. Little Giant Pump/Franklin Electric (ACS series) or Engineer approved equal.

2.3. SINGLE-ZONE OUTDOOR UNITS

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Impact resistant plastic or steel with baked enamel finish with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing. Provide condenser coil with hail guards.

2. Compressor: Hermetically-sealed inverter –duty scroll compressor with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

B. Refrigerant: R-410A.

1. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid sub-cooler. Comply with AHRI 206/110.

2. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.

3. Fan: Aluminum-propeller type, directly connected to motor.

4. Motor: Permanently lubricated, with integral thermal-overload protection.

5. Low Ambient Kit: Permits operation down to 45 deg F.

6. Mounting Base: Polyethylene.

2.4. ACCESSORIES

A. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

1. Remote control devices are not an acceptable alternative.

B. Drain Hose: For condensate.

PART 3 - EXECUTION

3.1. INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install roof-mounted, compressor-condenser components on equipment supports. Anchor units to supports with removable, cadmium-plated fasteners.

D. Equipment Mounting:

1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s).

2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548.

E. Install and connect refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2. CONNECTIONS

A. Refer to section 232300, “Refrigerant Piping” and section 232113, “Hydronic Piping” for refrigerant and condensate drain piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

3.3. FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

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

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.4. STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.5. DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 238116

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SECTION 238216 – AIR COILS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes heating and cooling air coils.

1.2. SUBMITTALS

A. Product Submittals: For each type of product include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil. Include rated capacities, operating characteristics, and pressure drops for each air coil.

1.3. QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

B. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

C. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

PART 2 - PRODUCTS

2.1. GENERAL REQUIREMENTS

A. Performance Ratings: Hydronic and refrigerant coils shall be tested and rated according to AHRI 410 and ASHRAE 33. Electric resistance coils shall be listed and labeled according to NFPA 70 and assembled according to UL 1995.

2.2. HYDRONIC COILS

A. Description: Coils shall be factory tested to 300 psig and rated for a minimum working pressure of 200 psig and minimum temperature of 325 deg F. Coil tubes shall be ASTM B 743 seamless copper expanded into fin collars for permanent fin-tube bond and expanded into header for permanent leak-tight joints. Coil fins shall be copper or aluminum. Coil headers shall be cast-iron with drain and air vent tappings for coils 32-inches tall and less and seamless copper tube with brazed joints and prime coated for coils taller than 32-inches. Coil casings shall be minimum 16 gauge galvanized steel channel frame for slip-in or flanged mounting.

2.3. REFRIGERANT COILS

A. Description: Coils shall be factory tested to 450 psig and rated for a minimum working pressure of 300 psig. Coil tubes shall be ASTM B 743 seamless copper expanded into fin collars for permanent fin-tube bond and expanded into header for permanent leak-tight joints. Coil fins shall be copper or aluminum. Suction and distribution piping shall be ASTM B 88, Type L copper tube with brazed joints. Coil casings shall be minimum 16 gauge galvanized steel channel frame for slip-in or flanged mounting.

2.4. ELECTRIC RESISTANCE COILS

A. Description: Heating elements shall be open-coil resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, and fastened to supporting brackets. Coil casings shall be minimum 16 gauge galvanized steel channel frame for slip-in or flanged mounting.

1. High-Temperature Coil Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or casing.

2. Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.

3. Control Panel: Unit- mounted with disconnecting means and overcurrent protection with SCR modulating control; non-fused safety disconnect switch interlocked with heater terminal box cover; air flow proving switch; time delay relay; differential pressure switch; 24V control transformer; and automatic reset thermal cutouts pre-wired to the control circuit.

4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 by a qualified testing agency accepted by the Authority Having Jurisdiction and marked for intended location and application.

a. Listing agencies of electrical and mechanical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

2.5. DRAIN PANS

A. Description: Drain pans shall be stainless steel. Alternative materials, such as galvanized steel and plastic, are not acceptable. Construct insulated pans with drain connection at the lowest point(s) and comply with ASHRAE 62.1. Pans shall extend beyond coil length and width, upstream and downstream of coil face, and under coil header and exposed piping

PART 3 - EXECUTION

3.1. EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

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

3.2. INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

D. Install drain pan under each cooling coil. Connect to condensate trap and drainage.

E. Straighten bent fins on air coils.

3.3. CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to coils to allow service and maintenance.

C. Hydronic Coils: Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Section 239010 and other piping specialties are specified in Section 232116.

D. Refrigerant Coils: Connect refrigerant piping according to Section 232300.

E. Electric Resistance Coils: Ground equipment and connect wiring in accordance with NFPA 70 and Division 26.

END OF SECTION 238216

SECTION 238239 – UNIT HEATERS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes propeller unit heaters with hot-water and electric-resistance heating coils.

1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Close-Out Submittals:

1. Operation and Maintenance Data: For propeller unit heaters to include in emergency, operation, and maintenance manuals.

1.3. QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

B. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

C. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

D. For electric-resistance unit heaters, comply with UL 2021.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following for electric resistance unit heaters:

1. Markel
2. Modine
3. Reznor

4. Trane

B. Manufacturers: Subject to compliance with requirements, provide products by the following for hydronic unit heaters:

1. Modine

2. Sterling

3. Trane

4. Vulcan Radiator

2.2. DESCRIPTION

A. Assembly including casing, coil, fan, and motor in vertical and horizontal discharge configuration with adjustable discharge louvers.

2.3. HOUSINGS

A. Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heaters before shipping.

B. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

2.4. COILS

A. General Coil Requirements: Test and rate hot-water and steam propeller unit-heater coils according to ASHRAE 33.

B. Hot-Water Coil: Copper tube minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 325 deg F, with manual air vent. Test for leaks to 350 psig underwater.

C. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch. Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F at any point during normal operation.

1. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.

2. Wiring Terminations: Stainless-steel or corrosion-resistant material.

2.5. FAN AND MOTOR

A. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

B. Motor: Comply with requirements in Section 230513. Provide explosion-proof motor where indicated on the drawings.

2.6. CONTROLS

A. Control Devices: Wall-mounted thermostat.

PART 3 - EXECUTION

3.1. EXAMINATION

A. Examine areas to receive propeller unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before unit-heater installation.

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

3.2. INSTALLATION

A. Install propeller unit heaters to comply with NFPA 90A.

B. Install propeller unit heaters level and plumb.

C. Suspend propeller unit heaters from structure with all-thread hanger rods and elastomeric hangers. Hanger rods and attachments to structure are specified in Section 230529. Vibration hangers are specified in Section 230548.

D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

3.3. CONNECTIONS

A. Piping installation requirements are specified in Section 232113 and 232116 for hydronic coils and Section 232213 and 232216 for steam coils. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to propeller unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

D. For hydronic unit heaters, comply with safety requirements in UL 1995.

E. Unless otherwise indicated, install union and ball valve and dtrainer on supply-water connection and union and pressure-independent control valve on return-water connection of propeller unit heater. Hydronic specialties are specified in Section 232113 and 232116.

F. Ground equipment according to Division 26.

G. Connect wiring according to Division 26.

3.4. FIELD QUALITY CONTROL

A. Perform the following tests and inspections.

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

2. Operate electric heating elements through each stage to verify proper operation and electrical connections.

3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

3.5. DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain propeller unit heaters.

END OF SECTION 238239

SECTION 239000 – BAS GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes general requirements for control systems.

1.2. DESCRIPTION OF WORK

A. The Building Automation System (BAS) contractor shall provide including but not limited to sensors, devices, field controllers and panels, network controllers and servers, front end operator interface, software and any other hardware or software components for a fully functioning BAS system.

B. Provide graphics on the front-end server for each piece of equipment, terminal unit, system, and room pressurization monitor and/or control.

C. Provide BAS Commissioning. The process of ensuring that all building systems are installed and perform interactively according to the design intent, the systems are efficient and cost effective and meet the owner's operational needs, the installation is adequately documented, and that the Operators are adequately trained. It serves as a tool to minimize post-occupancy operational problems. It establishes testing and communication protocols to advance the building systems from installation to full dynamic operation and optimization.

D. Engineer/Commissioning Authority (CA) and Owner shall work with the Contractor and direct, coordinate, and oversee the Commissioning process and witness functional performance testing. Contractor is required to coordinate with both the Owner and CA to conduct the work and provide sufficient notification to both parties for all activities related to commissioning.

E. BAS Architecture Description:

1. Provide Tridium N4 or Approved Equivalent Network Level Controls. Provide NCUs as required to support field controllers. Provide Supervisor software on a new contractor-furnished workstation computer or on customer provided and maintained Windows Server Virtual Machine (VM). Graphics, trends, alarms, etc. shall be located on the Supervisor.

1.3. SUBMITTALS

A. Qualification Submittals: For installer.

B. Product Submittals:

1. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, installation guides, and startup instructions for each type of product indicated.

   a. BAS System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.

   b. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

   c. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.

2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

   a. Bill of materials of equipment indicating quantity, manufacturer, and model number.

   b. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.

   c. Wiring Diagrams: Power, signal, and control wiring.

   d. Details of control panel faces, including controls, instruments, and labeling.

   e. Written description of sequence of operation.

   f. Schedule of dampers including size, leakage, and flow characteristics.

   g. Schedule of valves including flow characteristics, pressure differentials, and flow coefficients (Cv).

   h. BAS System Hardware:

      1) Wiring diagrams for control units with termination numbers.

      2) Schematic diagrams and floor plans for field sensors and control hardware.

      3) Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

   i. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule and operator notations.

   j. Controlled Systems:

      1) Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.

      2) Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.

      3) Written description of sequence of operation including schematic diagram.

      4) Points list.

   k. Samples for Verification: For each color required, of each type of thermostat or sensor cover.

3. Display Graphics: Provide a sample of proposed display graphics for each screen page and a flowchart diagram showing how each screen will be linked to the other. Where there are multiple systems or equipment that are repetitive, it is acceptable to provide one and note it applies to others. For example, one terminal unit screen graphic may be submitted as an example to represent all the terminal units of that type for the project.

    a. Owner's Graphic Standards: The owner's graphic standards shall be followed.

4. Provide a complete list of any deviations of submitted products to the specification in this document.

5. Data Communications Protocol Certificates: Certify that each proposed BAS system component complies with ASHRAE 135 (BACnet), ANSI Standard ANSI/CEA-709.1 (LonTalk), or MODBUS protocol specification conformance, as applicable.

6. Listing of Products: Certify that each proposed BAS system component is listed with BACnet Testing Lab (BTL), are marked with "LONMARK Compliant" and display the "LONMARK" logo or have been tested per the Modbus Conformance Testing Program, as applicable.

C. Construction Submittals:

1. Checkout Sheets

    a. Prior to startup of any equipment, contractor will provide manufacturer checkout sheets for each piece of equipment.

    b. Checkout sheets will contain at a minimum:

        1) Equipment name and location.

        2) Associated controller address (MAC or Node ID), name, type and instance number.

        3) Provide documentation of testing and calibration for each input and output. Submit for Engineer review.

D. Close-Out Submittals:

1. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals, including the following:

    a. Maintenance instructions and lists of spare parts for each type of control device.

    b. Interconnection wiring diagrams with identified and numbered system components and devices.

c. Keyboard illustrations and step-by-step procedures indexed for each operator function.

d. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

e. Calibration records and list of set points.

f. BAS Checkout Report: Controls system point-to-point checkout list to include the following: all physical points (excluding software points and/or setpoints), technician's initials, and dates of the point checkout.

g. Contractor verification of 100 percent of all control and monitoring points and all control sequences prior to Engineer witness.

2. Software and Firmware Operational Documentation: Include the following:

a. Software operating and upgrade manuals for all software required to program and maintain the system.

b. Program Software Backup: On a magnetic media or compact disc, complete with data files.

c. Device address list.

d. Printout of software application and graphic screens.

e. Software license required by and installed for BAS workstations and control systems.

3. Software Back-Up Electronic Files.

1.4. QUALITY ASSURANCE

A. The building automation system (BAS) shall be furnished, engineered, installed, tested and calibrated by factory certified technicians qualified for this work. The contractor shall be factory authorized in good standing with the manufacturer and located within 100 miles of the project site. Factory trained technicians shall provide instruction, routine maintenance, and emergency service within 24 hours upon receipt of request. A full-time on-site experienced project manager for this work shall be responsible for the direct supervision of the installation and start-up of the system.

1. Upon request, installer shall present records of successful completion of factory training courses.

2. Upon request, the installer shall provide a letter from the manufacturer that they are a Factory Authorized installer in good standing with the Manufacturer.

3. Upon request, the installer shall provide a list of 10 projects of similar scope and complexity within the past 5 years with the project owner's contact information.

B. Comply with UL 916 for Energy Management Systems.

C. Comply with UL 864 for Smoke Control System components.

D. Control panels, new and modified, shall comply with UL 508A. Field-built or modified panels shall be inspected, listed and labeled in the field or replaced with an equivalent shop-built panel that is listed and labeled.

E. Comply with ASHRAE 135 for BAS system components.

1. Local and Terminal Control Units shall be BACnet Testing Lab (BTL) listed.

A. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

B. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

C. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC). Comply with NC General Statute 66-25.

1.5. DELIVERY, STORAGE AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

1.6. COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Verify all locations with Engineer prior to installation.

B. Coordinate equipment with the fire alarm system to achieve compatibility with equipment that interfaces with that system.

C. Coordinate sources of 120V power with the Electrical Contractor and Owner for control units, operator workstation and other devices. Extend power from sources as needed.

D. Coordinate location of data ports with the Electrical Contractor and Owner.

1.7. SEQUENCE OF OPERATION

A. Sequences of Operation are located on the control drawings. Submit standard sequences for incidental items not shown for Engineer approval.

1.8. EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Replacement Materials: One replacement diaphragm or relay mechanism for each unique valve motor, controller, thermostat, humidistat and positioning relay.

1.9. WARRANTY

A. Building Automation System: Parts and labor for 1 year from the date of completion. The Owner reserves the right to make changes to the BAS during the warranty period and such changes do not constitute a waiver of the warranty.

1. The Owner shall allow remote access to the BAS for diagnostic testing and monitoring during the warranty period.

2. Upon request, a technician shall be on site to resolve the Owner reported issue within 24 hours of it being reported if it has not been resolved remotely to the Owner's satisfaction.

B. Electronic Actuators: Parts and labor for 5 years from the date of completion.

PART 2 - PRODUCTS

2.1. GENERAL REQUIREMENTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Trane Tracer (Ensemble SC+) Controls by Brady Trane (Preferred Brand Bid Alternate No. 6)

2. Schneider Electric (EcoStructure Building Operation Series) installed by Schneider Electric.

3. Distech Controls (ECB/ECY Series) installed by CMS Controls (CMS); Climatec - formally Engineered Control Solutions (Climatec/ECS); Brady Trane (Brady); or Hoffman Building Technologies (HBT).

4. Honeywell (Optimizer Series, ILC Models) installed by MSS Controls (MSS); or Climatec - formally Engineered Control Solutions (Climatec/ECS).

B. Products by the BAS system manufacturer shall include user interface, controller software, application programming language and equipment and application controllers. Sensors, actuators, valves, dampers and other components may be manufactured by others as indicated.

2.2. GRAPHICS AND REPORTING

A. Floor Plan Graphics:

1. Provide floor plan graphics for all areas of the building(s) served by the BAS. Create floor plans with an appropriate level of detail based on the construction documents. Copying the construction document files is not acceptable as they usually contain too much detail to be legible on a single screen shot. Submit the proposed graphics with the Owner / Engineer for approval.

2. Provide links from floor plans to enlarge floor plan areas (zoom in feature). Provide links from enlarged floor plans to equipment diagrams.

3. Provide links from zone sensor locations on the floor plans to associated terminal equipment. Each temperature control zone shall be clearly indicated on the floor plans.

4. Coordinate room names and numbers with the Owner and building signage. Often the final room names and numbers differ from the construction documents.

B. Equipment / Terminal Unit Graphics:

1. Provide an equipment diagram indicating each component and sensor with a link to the written sequence of operation, maintenance notes, etc. Each diagram shall indicate all data points. Parameters shall be overridden / changed from the graphic.

2. Provide a link to associated equipment for each diagram. (For example, a terminal unit might have a link at the reheat coil to the heating water plant and the terminal box to the AHU feeding it.)

3. Provide a location for any point associated with an equipment diagram but located remotely. For example, a duct-mounted pressure sensor in the AHU diagram might be indicated to be 'Located AFC in 24x12 SA duct in Corridor 100 outside Room 101'.)

4. Terminal Unit Graphics: Typical terminal unit graphics shall include:

a. Minimum and maximum flow setpoints

b. Heating flow setpoints

c. Zone heating and cooling temperature, high and low humidity and carbon dioxide high limit setpoints (if applicable)

d. Terminal unit percent of maximum heating and cooling

e. Occupancy control mode and status

f. Alarm status.

g. Time and date

h. Outside air temperature

C. Alarm Reporting:

1. Alarm Tag: Each alarm shall have a unique description tag, date and time. The tag shall be easily understood without the need to translate abbreviated or coded descriptions. The OWS shall be able to display, print and store each alarm message.

2. Alarm Prioritization: Each alarm type shall be assigned a priority level as defined by the Owner.

3. Alarm Acknowledgment: Each alarm shall be acknowledged by a recipient with password authorization via any form of operator interface. The alarm acknowledgement information including operator, date and time shall be saved with and append the alarm tag.

4. Alarm Summary Logs: Operators shall be able view all alarms and acknowledgements. They shall be sortable by date and time, operator, alarm type, and alarm priority.

5. OWS interface shall monitor all alarms. Alarm notifications shall be automatically sent to Owner staff via email and text messaging based on staff and alarm prioritization. The system's ability to report alarms shall not be affected by a breakdown in communications with other control panels on the network.

6. Alarms shall be defined by the Engineer's sequences of operation and the Owner.

D. Trend Reporting:

1. Trend Tag: Each trend shall have a unique description tag, date and time duration. The tag shall be easily understood without the need to translate abbreviated or coded descriptions. The OWS shall be able to display, print and store trend data.

2. Trend Summary Logs: Operators shall be able view all trend data. They shall be sortable by initiation date and time, operator, trend type.

3. Trend Data Collection: Data shall be exported to a compressed file on the server in MS Excel or MS Access format. Data shall be able to be stored without over-writing the collected data files for no less than one year.

4. Initial trends shall be defined by the Engineer's sequences of operation. Final trends at project completion shall be determined by the Engineer and Owner once the building systems are fully operational and functioning properly.

E. As-Builts:

1. A link to the schematics, wiring diagrams, and sequences of operation in PDF format shall be displayed on the equipment graphic to enable the owner to view them from the graphic interface to assist in troubleshooting of the system.

2.3. UNINTERRUPTABLE POWER SUPPLIES (UPS)

A. Uninterruptable Power Supplies (UPS): Provide individual UPS to maintain system operation for short-term power interruptions up to 30-minutes. Manufactured by APC or Engineer approved equal.

1. Operator Workstation.

2. Servers.

3. Network Control Units (NCU's)

4. Critical Control Panels as defined by the Engineer based on submitted controls architecture.

2.4. SURGE PROTECTION

A. Surge Protection Devices: Provide lightening / surge protection devices to protect the BAS system. Ditek (DTK-LVLP series), Emerson Edco (PC642 series), PE manufacturing (DRS series) or equal.

B. Provide surge protection on the following equipment:

1. Operator Workstation

2. Servers

3. Network Control Units (NCU's)

4. Critical Control Panels as defined by the Engineer based on submitted controls architecture.

5. Control cable, including but not limited to input/output wiring, communication bus, or any other wire at every point it exits and enters the building.

C. Where a UPS is also being provided, it may be combined with the surge protection requirements.

2.5. CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring shall comply with Section 230511 and Division 26.

2.6. ELECTRICAL CONNECTIONS AND ENCLSOSURES

A. Provide 24V transformers for all control equipment fed by low-voltage (100 to 600 V) power feeders. Coordinate the exact requirements with the Electrical Contractor.

B. Comply with the requirements of Section 230511 and Division 26.

PART 3 - EXECUTION

3.1. EXAMINATION

A. Work and/or systems installed under this Division shall be fully functioning prior to demonstration and acceptance. Contractor shall start, test, adjust, and calibrate all work and/or systems under this Contract, as described below.

B. Verify that power supply is available to control units and operator workstation.

C. Verify that duct, pipe, and equipment-mounted devices are installed before proceeding with installation.

3.2. HARDWARE AND SOFTWARE INSTALLATION

A. Install software in NCUs, Operator Workstation(s), Server(s), as required, and in accordance with 239030. Implement all features of programs to specified requirements and as appropriate to sequence of operation.

1. Sequence of operation programming shall exist on the controller level with default values set to allow continuous, stable system operation in case of network failure.

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. Graphics: The web browser view of the graphics shall be the same as provided by the Operator Interface Graphic Software when accessed directly on the Owner’s network. The web browser graphics shall support URL hypertext links for other locations on the internet and intranet.

1. All graphic screens shall indicate date, time, and outside air temperature, and outside air relative humidity.

2. All valves and dampers shall display position as percent open.

D. Trending: Unless otherwise noted on construction documents or points lists the following points should be trended at the defined intervals:

1. Analog Inputs: 15 Minute (Max) Interval.

2. Analog Outputs: 15 Minute (Max) Interval.

3. Setpoints: COV and at least once every 24 hours.

4. Digital points: COV and at least once every 24 hours.

3.3. ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Extend 120V power circuits from points provided to control voltage transformers. Where dedicated junction boxes have been provided, coordinate the exact locations with the Electrical Contractor. Where they have not, coordinate the spare circuit breakers to be used with the Electrical Contractor or Owner.

B. Install raceways, boxes, and cabinets according to Section 230511 and Division 26.

C. Install building wire and cable according to Section 230511 and Division 26.

D. Install signal and communication cable according to Section 230511 and Division 26. Comply with manufacturer's installation guidelines.

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.

2. Install exposed cable in raceway.

3. Install concealed cable in raceway.

4. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.

5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.

6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.

7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

E. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

F. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

G. Install surge protection in accordance with manufacturer's guidelines.

3.4. FIELD QUALITY CONTROL

A. Description: Inspect, test, verify and demonstrate equipment, control components and sequences of operation device-by-device and line-by-line for Engineer approval prior to Owner Acceptance.

1. Coordinate efforts with the Owner, Engineer, Commissioning Agent (if applicable), Construction Manager, Mechanical Contractor, Fire Alarm Contractor and TAB Contractor.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and installations, including connections.

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

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

C. Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.

2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.

3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.

4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by BAS system manufacturer. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.

5. Test Equipment: Use an optical fiber time domain reflectometer for testing of length and optical connectivity.

6. Test Results: Record test results and submit copy of test results for Project record.

3.5. BAS SYSTEM VERIFICATION

A. Check installed products before continuity tests, leak tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Review the manufacturer’s installation instructions and validate that the device is installed in accordance with them.

E. Control Damper Checkout:

1. Verify that control dampers are installed correctly for flow direction.

2. Verify that proper blade alignment, either parallel or opposed, has been provided.

3. Verify that damper frame attachment is properly secured and sealed.

4. Verify that damper actuator and linkage attachment is secure.

5. Verify that actuator wiring is complete, enclosed and connected to correct power source.

6. Verify that damper blade travel is unobstructed.

7. Verify fail position, stroke and range is correct.

F. Control Valve Checkout:

1. Verify that control valves are installed correctly for flow direction.

2. Verify that valve body attachment is properly secured and sealed.

3. Verify that valve actuator and linkage attachment is secure.

4. Verify that actuator wiring is complete, enclosed and connected to correct power source.

5. Verify that valve ball, disc or plug travel is unobstructed.

6. Verify fail position.

7. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

G. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.

2. Verify that attachment is properly secured and sealed.

3. Verify that conduit connections are properly secured and sealed.

4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.

5. Inspect instrument tag against approved submittal.

6. For flow instruments, verify that recommended upstream and downstream distances have been maintained.

7. For temperature instruments:

a. Verify sensing element type and proper material.

b. Verify length and insertion.

3.6. BAS SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

1. Verify voltage, phase and hertz.

2. Verify that protection from power surges is installed and functioning.

3. Verify that ground fault protection is installed.

4. If applicable, verify if connected to UPS unit.

5. If applicable, verify if connected to a backup power source.

6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.7. BAS SYSTEM I/O TESTING, ADJUSTING AND CALIBRATION

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

F. Check each instrumentation device by making a comparison between the BAS display and the reading at the device. Record the measured value and displayed value for each device in the BAS Checkout Report.

G. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

H. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

I. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

J. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

K. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.

2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.

3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

L. Digital Signals:

1. Check digital signals using a jumper wire.

2. Check digital signals using an ohmmeter to test for contact making or breaking.

3. Check each digital input point by making a comparison between the BAS display and the state of the sensing device. Record the results for each device in the BAS Checkout Report.

M. Control Dampers:

1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 50 percent open, to 100 percent closed, to 50 percent closed, and back to 100 percent open.

2. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.

3. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

4. Check each control damper by making a comparison between the BAS display and the position at the device. Record the commanded damper, actual position, and position feedback when applicable for each device in the BAS Checkout Report.

5. If actual damper position doesn’t reasonably correspond, replace actuator.

N. Control Valves:

1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 50 percent open, to 100 percent closed, to 50 percent closed, and back to 100 percent open.

2. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.

3. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

4. Check each control valve by making a comparison between the BAS display and the position at the device. Record the commanded value, actual position, and position feedback when applicable for each device in the BAS Checkout Report.

5. If actual valve position doesn't reasonably correspond, replace actuator.

O. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

P. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

Q. Switches: Calibrate switches to make or break contact at set points indicated.

R. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.

2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

S. Exercise each binary point.

T. For every I/O point in BAS system, read and record each value at operator workstation, at BAS controller and at field instrument simultaneously. Value displayed at operator workstation, at BAS controller and at field instrument shall match. Report results in BAS Checkout Report.

U. Prepare and submit a BAS Checkout Report documenting results for each I/O point in BAS system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

3.8. BAS CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

1. Test every I/O point connected to BAS controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.

2. Test every I/O point throughout its full operating range.

3. Test every control loop to verify operation is stable and accurate.

4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.

5. Test and adjust every control loop for proper operation according to sequence of operation.

6. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the BAS Checkout Report. Except from a startup, maximum allowable variance from set point for controlled

variables under normal load fluctuations shall be as follows. Within 3 minutes of any upset (for which the system has the capability to respond) in the control loop, tolerances shall be maintained (exceptions noted):

a. Duct air temperature: Plus or minus 1 deg F.

b. Space Temperature: Plus or minus 2 deg F.

c. Chilled Water: Plus or minus 1 deg F.

d. Hot water temperature: Plus or minus 3 deg F.

e. Duct pressure: Plus or minus 0.1-inches w.g.

f. Water pressure: Plus or minus 1 psid.

g. Duct or space Humidity: Plus or minus 5 percent.

h. Air flow control: Plus or minus 5 percent of setpoint velocity.

7. Test software and hardware interlocks for proper operation. Correct deficiencies.

8. Operate each analog point at the following:

a. Upper quarter of range.

b. Lower quarter of range.

c. At midpoint of range.

3.9. BAS SYSTEM VALIDATION TESTS

A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.

B. After approval of Test Plan, execute all tests and procedures indicated in plan.

C. After testing is complete, submit completed test checklist.

D. Pretest Checklist: Submit the following list with items checked off once verified:

1. Detailed explanation for any items that are not completed or verified.

2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.

3. HVAC equipment motors operate below full-load amperage ratings.

4. Required BAS system components, wiring, and accessories are installed.

5. Installed BAS system architecture matches approved Drawings.

6. Control electric power circuits operate at proper voltage and are free from faults.

7. Required surge protection is installed.

8. BAS system network communications function properly, including uploading and downloading programming changes.

9. Using BACnet protocol analyzer, verify that communications are error free.

10. Each controller's programming is backed up.
11. Equipment, products, tubing, wiring cable, and conduits are properly labeled.
12. All I/O points are programmed into controllers.
13. Testing, adjusting, and balancing work affecting controls is complete.
14. Dampers and actuators zero and span adjustments are set properly.
15. Each control damper and actuator goes to failed position on loss of power.
16. Valves and actuators zero and span adjustments are set properly.
17. Each control valve and actuator goes to failed position on loss of power.
18. Meter, sensor and transmitter readings are accurate and calibrated.
19. Control loops are tuned for smooth and stable operation.
20. View trend data where applicable.
21. Each controller works properly in standalone mode.
22. Safety controls and devices function properly.
23. Interfaces with fire-alarm system function properly.
24. Electrical interlocks function properly.
25. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphic are created.
26. Record Drawings are completed.

E. Test Plan:

1. Prepare and submit a validation test plan including test procedures for performance validation tests.
2. Test plan shall address all specified functions of BAS system and sequences of operation.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include a test checklist to be used to check and initial that each test has been successfully completed.
6. Submit test plan documentation 10 business days before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in BAS system.
    a. Verify analog I/O points at operating value.
    b. Make adjustments to out-of-tolerance I/O points.
        1) Identify I/O points for future reference.

2) Simulate abnormal conditions to demonstrate proper function of safety devices.

3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.

2. Simulate conditions to demonstrate proper sequence of control.

3. Readjust settings to design values and observe ability of BAS system to establish desired conditions.

4. After 24 Hours following Initial Validation Test:

a. Re-check I/O points that required corrections during initial test.

b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.

5. After 24 Hours of Second Validation Test:

a. Re-check I/O points that required corrections during second test.

b. Continue validation testing until I/O point is normal on two consecutive tests.

6. Completely check out, calibrate, and test all connected hardware and software to ensure that BAS system performs according to requirements indicated.

7. After validation testing is complete, prepare and submit a report indicating all I/O points that required correction and how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

G. BAS System Network Bandwidth Test:

1. Test network bandwidth usage on all BAS system networks to demonstrate bandwidth usage under BAS system normal operating conditions.

2. To pass, none of BAS system networks shall use more than 70 percent of available bandwidth under normal operation.

3.10. BAS SYSTEM WIRELESS NETWORK VERIFICATION

A. BAS system Installer shall design wireless BAS system networks to comply with performance requirements indicated.

B. Installer shall verify wireless network performance through field testing and shall document results in a field test report.

C. Testing and verification of all wireless devices shall include, but not be limited to, the following:

1. Speed.

2. Online status.

3. Signal strength.

3.11. FINAL REVIEW

A. Submit written request to Engineer and Construction Manager when BAS system is ready for final review. Written request shall state the following:

1. BAS system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.

2. BAS system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.

3. BAS system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.

4. BAS system is complete and ready for final review.

B. Review by Engineer and Construction Manager shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Should more than two reviews be required, BAS system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by BAS system manufacturer and Installer before making the review.

E. Prepare and submit closeout submittals.

F. BAS system final review shall include a demonstration to parties participating in final review.

1. Coordinate the demonstration 2 weeks in advance with representatives of the Owner, Engineer, Commissioning Agent (if applicable), Construction Manager, Mechanical Contractor, Fire Alarm Contractor and TAB Contractor.

2. Provide staff familiar with BAS system installed to demonstrate operation of BAS system during final review.

3. Provide testing equipment to demonstrate accuracy and other performance requirements of BAS system that is requested by reviewers during final review.

4. Demonstration shall include a detailed review of the control sequences for each system and piece of equipment.

3.12. EXTENDED OPERATION TEST

A. Extended operation test is intended to simulate normal operation of BAS system by Owner.

B. Operate BAS system for an operating period of 28 consecutive calendar days following project completion. Coordinate exact start date of testing with Owner.

C. Provide an operator familiar with BAS system installed to man an operator workstation.

D. During operating period, BAS system shall demonstrate correct operation and accuracy of monitored and controlled points as well as operation capabilities of sequences, logs, trends, reports, specialized control algorithms, diagnostics, and other software indicated.

1. Correct defects of hardware and software when it occurs.

E. Definition of Failures and Downtime during Operating Period:

1. Failed I/O point constituting downtime is an I/O point failing to perform its intended function consistently and a point physically failed due to hardware and software.

2. Downtime is when any I/O point in BAS system is unable to fulfill its' required function.

3. Downtime shall be calculated as elapsed time between a detected point failure as confirmed by an operator and time point is restored to service.

4. Maximum time interval allowed between BAS system detection of failure occurrence and operator confirmation shall be 0.5 hours.

5. Downtime shall be logged in hours to nearest 0.1 hour.

6. Power outages shall not count as downtime but shall suspend test hours unless systems are provided with UPS and served through a backup power source.

7. Hardware or software failures caused by power outages shall count as downtime.

F. During operating period, log downtime and operational problems are encountered.

1. Identify source of problem.

2. Provide written description of corrective action taken.

3. Record duration of downtime.

4. Maintain log showing the following:

a. Time of occurrence.

b. Description of each occurrence and pertinent written comments for reviewer to understand scope and extent of occurrence.

c. Downtime for each failed I/O point.

d. Running total of downtime and total time of I/O point after each problem has been restored.

5. Log shall be available to Owner for review at any time.

G. For BAS system to pass extended operation test, total downtime shall not exceed 1-percent of total point-hours during operating period.

1. Failure to comply with minimum requirements of passing at end of operating period indicated shall require that operating period be extended one consecutive day at a time until BAS system passes requirement.

H. Evaluation of BAS system passing test shall be based on the following calculation:

1. Downtime shall be counted on a point-hour basis where total number of BAS system point-hours is equal to total number of I/O points in BAS system multiplied by total number of hours during operating period.

2. One point-hour of downtime is one I/O point down for one hour. Three points down for five hours is a total of 15 point-hours of downtime. Four points down for one-half hour is 2 point-hours of downtime.

3. Example Calculation: Maximum allowable downtime for 30-day test when BAS system has 1000 total I/O points (combined analog and binary) and has passing score of 1 percent downtime is computed by 30 days x 24 hr/day x 1000 points x 1 percent equals 7200 point-hours of maximum allowable downtime.

I. Prepare test and inspection reports.

3.13. ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of project completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to 2 visits to Project during other-than-normal occupancy hours for this purpose.

3.14. MAINTENANCE SERVICE

A. Maintenance Service: Beginning at project completion, maintenance service shall include 12 months' full maintenance by BAS system manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.15. SOFTWARE BACK-UPS

A. Upon completion including final adjustments, backup all data to associated NCUs and/or front-end servers/supervisors.

B. Provide two (2) complete back-up electronic Copies of software files for each operator workstation, server, diagnostic terminal unit and equipment controller. The software files shall include all data and software files needed to completely reset or re-install the software for the entire project including a text file with a written description of the reinstall process. Each copy shall be saved to an external hard drive.

1. External Hard Drive: 2 TB, 3.0/2.0 USB, portable hard-drive manufactured by Seagate, Toshiba or Western Digital.

C. All software required to operate, maintain, and program the system becomes the property of the owner.

3.16. SOFTWARE UPDATES

A. At 12-months from the date of completion, update the BAS software to the most recent release. The update(s) shall be scheduled with the Owner and performed under their direct supervision. Verify proper operation after the installation and correct any problems created by the installation process.

1. Software update shall include all labor, licensing and associated fees.

2. If the Owner has an established energy management system serving buildings outside the scope of this project, ensure the software is compatible with the existing system without needing to update it.

3.17. DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Training will provide site specific information including but not limited to:

1. As-builts.

2. BAS checkout, startup and calibration report.

3. Controller replacement.

4. Software required to manipulate the system including programming.

END OF SECTION 239000

SECTION 239010 – BAS INSTRUMENTATION

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes instrumentation for building automation systems.

1.2. SUBMITTALS-

A. Comply with the requirements of Section 239000.

B. Product Submittals: Provide data for product indicating compliance with the requirements of this project.

C. Close-Out Submittals:

1. Operation and Maintenance Data: For instrumentation to include in operation and maintenance manuals.

1.3. QUALITY ASSURANCE

A. Comply with BAS general requirements in Section 239000.

1.4. COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Verify all locations with Engineer prior to installation.

B. Coordinate sources of 120V power with the Electrical Contractor and Owner for control devices. Extend power from sources as needed.

1.5. WARRANTY

A. Warranty: Provide one-year manufacturer's parts and labor warranty for each energy and flow meter.

1. Electronic Actuators: Parts and labor for 5 years from the date of completion.

1.6. EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Replacement Materials: One replacement diaphragm or relay mechanism for each unique valve motor, controller, thermostat, humidistat and positioning relay.

PART 2 - PRODUCTS

2.1. SENSORS

A. Provide sensors as indicated in control diagrams and sequences of operation or as needed to perform the intended operations.

B. Sensors shall be vibration and corrosion resistant and designed for the intended use.

2.2. TEMPERATURE SENSORS, STANDARD ACCURACY

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Automation Components Inc. (ACI)

2. Building Automation Products Inc. (BAPI)

3. Distech

4. Honeywell

B. Description: Temperature sensor shall be thermistor or resistance temperature detector (RTD) type and compatible with BAS.

1. Accuracy: Plus or minus 0.5 deg F over 32 to 158 deg F range.

2. Operating Temperature: Minus 40 to 300 deg F.

C. Wall-Mounted Temperature Sensor: Sensors in white plastic enclosure with insulated backing.

1. LED display.

2. Set point adjustment.

3. Push button occupancy override switch.

D. Wall-Mounted Flat-Plate Temperature Sensor: Stainless steel, flat plate sensor that fits in a standard 2-inch by 4-inch junction box with tamperproof screws. Provide with insulated backing.

E. Outside Air Temperature (OAT) Sensor: Thermistor or RTD compatible with BMS installed in wall-mounted weatherproof enclosure with conduit entrance and aluminum LB with PVC sun and windscreen.

F. Duct-Mounted Single-Point Temperature Sensor: Rigid sensor sealed in 0.25-inch stainless steel probe of length between one-third and two-thirds of the duct width in duct-mounted metal housing with conduit entrance.

1. Single-point may be used in ducts where there is no air stratification possibilities. Sensor shall be mounted downstream to allow for sufficient mixing.

G. Duct-Mounted Averaging Element Temperature Sensor: Multi-point sensor, contained in a flexible copper or woven continuous metallic sheath, with length sized for duct.

1. Provide a minimum of 1 foot of sensing element for every 3 square-feet of duct/coil area. Multiple averaging elements may be required.

2. Averaging elements shall be used where ducts are prone to stratification, and downstream of heating/cooling coils.

3. Where multiple sensors are provided, sensors may be wired in a series-series, parallel-parallel pattern (requires four or nine sensors) in lieu of multiple inputs.

4. Plenum rated sheaths are not acceptable.

H. Thermowell-Mounted Immersion Temperature Sensor: Rigid sensor sealed in 0.25-inch stainless steel probe with 3-part moisture protection system and minimum length equal to 20-percent of pipe width. Provide machined, single-piece brass or stainless steel thermowell compatible with sensor housing.

I. Strap-On Piping Aquastat Temperature Sensor: Snap acting SPDT, pipe mount, automatic or manual reset switch (as indicated on drawings) that trips if temperature sensed is equal to or above setpoint. Sensing range appropriate for application.

2.3. THERMOSTATS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Automation Components Inc. (ACI)

2. Honeywell

3. Schneider Electric

B. Digital Stand-Alone Thermostat: Electric, solid-state, microcomputer-based room thermostat.

1. Automatic switching from heating to cooling.

2. Preferential rate control to minimize overshoot and deviation from set point.

3. Set up for four separate temperatures per day, with individual programming for each day of the week (4 programs per day, 7 days per week, 28 potential programs).

4. Instant override of set point for continuous or timed period from 1 hour to 31 days.

5. Short-cycle protection.

6. Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable and fan on-auto.

7. Powered off unit 24Vac transformer, with solid-state memory in which programming is retained on power failure. Battery acceptable only for time and date upkeep during power failure.

8. Thermostat display features include the following: time of day, actual room temperature, programmed temperature, programmed time, duration of timed override, day of week, and system mode indications include "HEATING", "OFF", "FAN AUTO" and "FAN OFF".

9. Combination Thermostat, Humidistat, Carbon Dioxide, and/or Occupancy Sensor: Where there is a requirement for a thermostat with humidistat, carbon dioxide, and/or occupancy sensing functions at the same location, provide combination unit. The individual sensors must each meet the specifications details herein.

10. Provide remote sensing element (electronic sensor) as required for application.

C. Line-Voltage Stand-Alone Combination Thermostat and Fan Switch: Line-voltage thermostat with push-button or lever-operated fan switch.

1. Label switches "FAN ON-OFF", "FAN HIGH-LOW-OFF" or "FAN HIGH-MED-LOW-OFF" as applicable.

2. Mount on single electric switch box.

D. Line-Voltage Stand-Alone On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.

1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.

2. Selector Switch: Integral, manual on-off-auto.

E. Low-Voltage Stand-Alone On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-free, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.

F. Electric Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual automatic reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.

1. Bulb Length: Minimum 20 feet.

2. Quantity: One thermostat for every 20 sqft. of coil surface.

G. Electric High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual automatic reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above set point.

1. Bulb Length: Minimum 20 feet.

2. Quantity: One thermostat for every 20 sqft. of coil surface.

2.4. HUMIDITY SENSORS, STANDARD ACCURACY

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Automation Components Inc. (ACI)

2. Building Automation Products Inc. (BAPI)

3. Distech

4. Honeywell

B. Description: Laser-trimmed thermoset polymer-based capacitive-type sensor, 4-20mA or 0-10Vdc output proportional to relative humidity range of 0% to 100% and compatible with 24 Vac/dc power supply and BAS.

1. Accuracy: Plus or minus 3-percent over 10 to 90-percent range.

2. Measurement Range: 0 to 100-percent.

3. Operating Temperature: Minus 40 to 140 deg F.

C. Wall-Mounted Relative Humidity Sensor: Sensors in white plastic enclosure with insulated backing.

D. Outside Air Relative Humidity (OAH) Sensor: Sensor installed in wall-mounted weatherproof enclosure with conduit entrance and aluminum LB with PVC sun and windscreen.

E. Duct-Mounted Relative Humidity Sensor: Sensor with 9-inch long probe in duct-mounted plenum-rated housing with conduit entrance.

2.5. COMBINATION SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Automation Components Inc. (ACI)
2. Building Automation Products Inc. (BAPI)
3. Distech
4. Honeywell
5. Vaisala

B. Combination Wall-Mounted Temperature and Humidity Sensors: Sensors in white plastic enclosure with insulated backing.

1. Where monitoring temperature and relative humidity are required at the same location, provide combination relative humidity and temperature sensors. Individual sensors must meet each of the specification details herein.
2. Where required, combination relative and humidity sensors shall have the ability to output additional parameters including dew point, enthalpy and wet bulb temperature.
3. LED display.
4. Set point adjustment.
5. Push button occupancy override switch.

C. Combination Wall-Mounted Sensor Modules: Sensors which measure multiple conditions as noted such as temperature, relative humidity, pressure, etc. in white plastic enclosure with insulated backing.

1. Where monitoring multiple conditions are required at the same location, provide combination sensor modules. Individual sensors must meet each of the specifications details herein.
    a. Where carbon dioxide is provided beside temperature and/or humidity sensors, it shall be provided separately and not combined into a single sensor.

2. Where required, combination sensor modules shall have the ability to output additional parameters including dew point, enthalpy and wet bulb temperature.

3. LED display.

4. Set point adjustment.

5. Push button occupancy override switch.

D. Combination Duct-Mounted Temperature and Humidity Sensors:

1. Where monitoring temperature and relative humidity are required at the same location, provide combination relative humidity and temperature sensors. Individual sensors must meet each of the specification details herein.

2. Where required, combination relative and humidity sensors shall have the ability to output additional parameters including dew point, enthalpy and wet bulb temperature.

2.6. DRY (AIR) PRESSURE SENSORS, STANDARD ACCURACY

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Automation Components Inc. (ACI)

2. Honeywell

3. Setra

4. Veris

B. General Requirements: Diaphragm pressure transducer and amplifier type sensor, 4-20mA or 0-10Vdc output proportional to pressure range and compatible with 24 Vac/dc power supply and BAS. Each sensor shall have a local display.

1. Accuracy: Plus or minus 1-percent of full scale output range.

2. Operating Temperature Range: -4 to 140 deg F.

3. Burst Pressure: 5 psid.

C. Duct-Mounted Static Pressure Sensors:

1. Uni-directional.

2. Measurement Range: 0 to 6 inches wg for low and medium pressure applications and higher as required for high pressure applications.

D. Room Pressure Sensors:

1. Bi-directional.

2. Measurement Range: Minus 0.2 to positive 0.2 inches wg.

E. Building Pressure Sensors:

1. Bi-directional.

2. Measurement Range: Minus 0.2 to positive 0.2 inches wg.

3. Provide outside air reference kit (Dwyer A-306 or equivalent) with tubing, mounting bracket and required hardware.

F. Air Filter / Coil Differential Pressure Sensors:

1. Uni-directional.

2. Measurement Range: 0 to 2-inches wg and higher as required.

2.7. DRY (AIR) PRESSURE SENSORS, HIGH ACCURACY

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Phoenix Controls

2. Setra

B. General Requirements: All requirements of standard accuracy dry pressure sensors are applicable, except where more stringent requirements below. Sensor shall be provided with NIST traceable calibration certificate.

1. Accuracy: Plus or minus 0.5-percent of full scale output range.

2. Operating Temperature Range: -4 to 140 deg F.

3. Burst Pressure: 5 psid.

2.8. DRY (AIR) PRESSURE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cleveland Controls

2. Dwyer

B. General Requirements: Diaphragm pressure switch with SPDT contacts and setpoint adjustment knob. Sensor shall be uni-directional and be manual or automatic reset in accordance with drawings.

1. Accuracy: Plus or minus 2 percent of full scale output.

2. Measurement Range: 0 to 0.25-inches wg for building and duct pressurization applications; 0 to 1.50-inches wg for filter alarms; and 0 to 12-inches wg for high static alarms.

a. Status Inputs for Fans: Adjustable range of 0 to 6-inches wg.

3. Operating Temperature Range: -4 to 185 deg F.

C. “Paddle-style” air flow switches are not allowed. Use dry pressure switch in lieu of paddle.

2.9. DRY (AIR) FLOW SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equivalent:

1. McDonnell & Miller

B. General Requirements: Explosion proof air flow paddle SPDT switch suitable for Class 1, Division 1 or Division 2 hazardous classified areas.

C. Ambient temperature 120 deg F max, media temperature 275 deg F max.

D. Select switches for appropriate flow and velocity ranges.

E. Provide intrinsic safety barriers, wiring, and seals.

2.10. WET (WATER) PRESSURE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cleveland Controls
2. Dwyer

B. General Requirements: Diaphragm pressure switch with SPDT contacts and setpoint adjustment knob. Sensor shall be uni-directional and be manual or automatic reset in accordance with drawings.

1. Accuracy: Plus or minus 2 percent of full scale output.
2. Measurement Range: 0 to 2 times the set point or anticipated pressure.
    a. Status Inputs for Pumps: Adjustable range of 8 to 60 psig, piped across pump.
3. Operating Temperature Range: -20 to 200 deg F.

C. "Paddle-style" water flow switches are not allowed. Use wet pressure switch in lieu of paddle.

2.11. CARBON DIOXIDE (CO2) SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Honeywell
2. Veris
3. Vaisala

B. General Requirements: Non-dispersion infrared (NDIR) type sensor, 4-20mA or 0-10Vdc output proportional to carbon dioxide (CO2) range and compatible with 24 Vac/dc power supply and BAS. Sensor shall have local display.

1. Accuracy: Plus or minus 2 percent of reading or 30 ppm, whichever higher.
2. Measurement Range: 0 to 2000 ppm.
3. Operating Temperature Range: 32 to 120 deg F.
4. Standard Calibration: No maintenance or periodic sensor replacement needed. The sensor shall have a 5-year calibration interval, utilizing an automatic unoccupied period calibration.
5. Where the building operates 24 hours per day (no unoccupied periods), sensors capable of maintaining accuracy without the automatic unoccupied period calibration sequence will be installed.

C. Wall-Mount Carbon Dioxide Sensors: Sensors with plastic enclosure that fits on a standard 2-inch by 4-inch junction box.

D. Duct-Mount Carbon Dioxide Sensors: Sensors with sampling tube and duct-mounted metal housing with conduit entrance.

2.12. INDOOR AIR QUALITY SENSORS

A. Carbon Monoxide (CO) Sensors: Electrochemical type sensor with 4-20Ma or 0-10 Vdc output of Carbon Monoxide sensed compatible with BAS system. Unit shall be complete with 85 Db audible alarm and have visual output reading via an LCD display of the gas sensed. Provide two (2) relay contacts, at minimum, per sensor, to indicate CO warning level (initially set at 50ppm) and CO alarm level (initially set at 100ppm) for each sensing point. The proposed sensor locations shall be submitted at the shop drawing stage and shall be amended as directed by the Owner and/or Engineer.

1. Range: 5 percent accuracy from 0 to 300 ppm.

2. Temperature: 32 to 120 deg F.

3. Calibration: Factory calibrated and only requires calibration after a minimum one (1) year service.

B. Oxygen Sensors: Solid-state zircon cell sensor with 4 to 20 Ma output.

1. Accuracy: 5 percent of reading.

2. Temperature: 32 to 120 deg F.

2.13. RELAYS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Functional Devices
2. IDEC
3. Veris

B. General Requirements: Relays shall be electrically rated for each application, minimally SPDT with 10A (resistive) contacts, and plenum rated. They shall include LED indicator light and hand-off-auto (HOA) unless otherwise specified. Relays shall be UL-listed and mounted in NEMA 1 enclosure for indoor applications and NEMA 4 for outdoor.

C. BAS Panel-Mounted Relays: Socket ("ice-cube") style with mounting base and replaceable relay. Relays in panel will be screw terminal terminations; relays with wiring whip from factory are not allowed for panel mounting. HOA not required if controller has internal HOA or output being controlled has HOA (i.e. VFD).

D. Nipple-Mounted Relays: Enclosed relay compatible with conduit knockout. Acceptable for field use. With or without factory-provided wiring whip. HOA not required if output being controlled has HOA (i.e. VFD).

E. Track-Mounted Relays: Acceptable for use in terminal unit control panels. Screw terminal terminations. Track-mounted relays are not to be installed in field unless inside an equipment control panel (no track-mounted relays in electrical boxes). HOA not required if output being controlled has HOA (i.e. VFD).

F. Combination Motor Starter / Current Switch Relays: Allowed only for single-phase equipment and must be mounted such that pilot light is exposed (combination motor starter / current switch relays which install inside of motor starter/VFDs are not allowed). Relay and current switch must each meet the specifications details herein. HOA not required if output being controlled has HOA (i.e. VFD).

2.14. CURRENT SENSORS, SWITCHES AND TRANSFORMERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Automation Components Inc. (ACI)
2. Setra
3. Veris

B. General Requirements: Devices shall be rated for their associated motor load and voltage, have input and output isolation and have LED indication of status. Devices shall be selected based on application including but not limited to standard 60 hertz motors, variable speed controllers or electronically communicated motors (ECM's). Devices shall be UL-listed and mounted in NEMA 1 enclosure for indoor applications and NEMA 4 for outdoor.

1. Accuracy: 2 percent of full-scale output.
2. Measurement Range: 0 to 2 times the anticipated current.
3. Operating Temperature Range: Minus 30 to plus 140 deg F.

C. Current Status Switch: Self-powered current switch with normally open (NO) contacts for Go/No Go or On/Off status. Provide with adjustable trip point where applicable.

D. Current Sensor / Transducer: Sensor with 4-20 mA or 0-10Vdc output proportional to current draw.

E. Control Transformers: Transformer with 4-20 mA or 0-10Vdc output proportional to current draw.

2.15. DETECTION EQUIPMENT

A. Water Leak Detection Alarm: Adjustable-height multi-point water detection sensor constructed to be corrosion and abrasion resistant and configured for normally open or normally closed as required by the application with 24Vac/dc power supply. Provide remote-mounted sensing probe and cable as needed for each application. Dwyer (WD series) or equal.

1. Temperature: Minus 40 to positive 185 deg F.

B. Condensate Drain Pan Overflow Safety Switch: Low-voltage, float-type safety switch designed for condensate drain pan high-level alarm for unit shutdown and alarming. Little Giant Pump/Franklin Electric (ACS series) or equal.

C. Occupancy Override Switch: Low-voltage wall switch in a standard single-switch back box with momentary switch, green LED “on” indicator light, with white plastic faceplate. Hubbell (LVSM series) or equal.

D. Occupancy Sensor: Dual-technology passive infrared (PIR) and ultrasonic occupancy sensor with adjustable time delay of 5 to 45 minutes, daylight sensor lockout, sensitivity control, and 180-degree field of view with vertical sensing adjustment; for flush wall or ceiling mounting in standard metal outlet box. Provide sensor with LED light to indicate when motion is being detected during test and normal operation. Provide sensor with auxiliary dry contacts. Power supply to the sensor shall be 24Vdc, located within the outlet box and be plenum-rated.

1. Ceiling-Mounted Sensors: Cooper Lighting/Eaton (MicroSet Series), Hubbell (OMNI Series), Leviton (OSC Series), Lutron (LOS C Series) or Watt Stopper (LMDC Series).

2. Wall-Mounted Sensors: Hubbell (LightHAWK2 Series), Lutron (Maestro Series), Watt Stopper (LMDW Series).

2.16. STATUS SENSORS

A. Shaft-Mounted Limit Switches: SPDT/DPDT mercury-free, gravity-actuated mechanical switch with adjustable shaft connection.

B. Whisker Limit Switches: SPDT/DPDT mechanical whisker switch with adjustable trim arm.

2.17. MANUAL OVERRIDE DEVICES

A. Emergency Stop Buttons: ADA-compliant, red emergency pushbutton in white polycarbonate plastic enclosure with clear flip-up cover and stainless steel backplate. Button shall be reset by twisting or pulling out the button; a procedure that requires disassembly or a key is not acceptable. 120V or 24 V as needed. Provide label with indication of operation. Safety Technology International (STI) (Stopper Station series) or approved equal.

2.18. TRANSFORMERS AND CONTACTORS

A. Control Transformers: Class 2, sized and rated for application. Circuit breaker overcurrent protection; fused or internal overcurrent protection is not allowed. Transformers shall be sized so that connected load does not exceed 75 percent of rating. Functional Devices TR series or equal.

B. Power Contactors: NEMA ICS 2 AC general purpose magnetic contactor mounted in NEMA 1 enclosure for indoor locations and NEMA 4 for outdoor.

2.19. POWER MONITORING DEVICES

A. Voltage Transmitter (100 to 600 V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

2.20. ANNUNCIATION DEVICES

A. Visible Status / Alarm Devices: UL-listed; two color LED lights, with green and red polycarbonate lens and white ABS plastic enclosure, wall-mounted on an aluminum faceplate. Words, for example "Fume Hood (Number) Fan Status", shall be printed in minimum 1/2-inch high letters on the enclosure. Each light shall be steady or flashing as noted. 120V or 24 V as needed. Rockwell Automation (855W series) or approved equal.

2.21. ELECTRONIC ACTUATORS

A. Manufacturers: All valve actuators shall be supplied from a single manufacturer. All damper actuators shall be supplied from a single manufacturer. Provide actuators manufactured by one of the following:

1. Belimo
2. Honeywell
3. Schneider Electric (TAC Dura-Drive)

B. General Requirements: Direct-coupled type, motor-operated, electric and electronic actuators designed for minimum 60,000 full-stroke cycles at rated torque.

1. Voltage: 24Vac unless otherwise specified. 120V actuators may be allowed if coordinated by controls contractor with electrical contractor to provide local disconnect and power. Circuit must be fed from the same power panel as the equipment or control panel and a spare circuit must be available.

2. Power: Contractor is responsible for sizing control transformers based on the VA of the actuator(s) selected. Provide electronic overload protection throughout the entire operating range in both directions.

3. Coupling: V-bolt and V-shaped, toothed cradle. Bolt and set screw method of attachment is unacceptable.

4. Fail-Safe: Where indicated, provide actuator to fail via a mechanical spring return mechanism, to drive controlled device to an end position (open or close) on loss of power. Electronic fail-safe is not allowed, unless specifically reviewed and accepted by Engineer. Provide external, manual gear release on non-spring-return actuators.

5. Temperature Rating:

   a. Standard Dampers and Valves: Minus 22 to plus 122 deg F.

   b. Smoke Dampers: Minus 22 to plus 250 deg F.

6. Housing: Minimum NEMA Type 2, mounted in any orientation, for indoor locations and NEMA Type 3R, mounted in any orientation, for outdoor locations.

7. Stroke Time:

   a. Normal: 120 seconds or less from fully closed to fully open, or fully open to fully closed.

   b. Fast-Acting: 12 seconds open, 5 seconds closed unless otherwise noted.

8. Actuators shall operate related valve(s)/damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the valve/damper is subjected.

9. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the designed pump/fan shutoff pressure as a minimum requirement.

10. Select actuators to fail in desired position in the event of a power failure. See drawings for power failure modes.

11. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

12. Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.

13. Provide actuator enclosure with a heater and controller where required by application.

14. Comply with requirements in Section 230513.

C. Two-Position Actuators: Single direction, spring return or reversing (non-spring return) type.

D. Modulating Actuators:

1. Capable of stopping at all points across full range and starting in either direction from any point in range.

2. Control Input Signal:

   a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input, the actuator remains in the last position.

   b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero to 5-, zero- to 10-, 1 to 5- or 2- to 10-Vdc and 4- to 20-mA signals.

3. Floating Control: Floating control actuators shall be allowed only for damper and valve control for room terminal units where there is not a room pressurization requirement. Use of floating controls must be specifically requested by the contractor for specific spaces and reviewed by the engineer. Submission of floating control actuators without specific comment by the contractor for spaces and the resulting review by the Engineer does not constitute approval for use.

4. Pulse width modulation (PWM), or any other analog signal that is not specified above is not allowed.

E. Position Feedback: Where indicated, equip two-position actuators with auxiliary switches (SPDT) for remote monitoring of open and/or closed position. Point of open and/or closed position can be adjusted over the actuators range of operation (0-100%). Where indicated, equip modulating actuators with a position feedback through current and/or voltage signal for remote monitoring.

F. Run Time:

1. Normal: 120 seconds from closed to open or open to closed.

2. Fast-Acting: 12 seconds closed to open and 5 seconds open to closed unless otherwise noted.

a. Emergency System Components

b. Fuel Shut-Off Valves

2.22. HYDRONIC CONTROL VALVES

A. General Requirements: Factory fabricated of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated. Refer to Section 232119 for general information about valve construction and installation. Provide stainless steel internal components.

1. Control valves assemblies shall be provided and delivered from a single manufacturer as a complete assembly, with the actuator installed at the factory.

2. Control valves shall be two- or three-way as specified on the drawings.

3. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two and three-way valves but not less than 40 psig.

4. Provide with extended neck as required to accommodate insulation thicknesses as specified. Reference 230719 for insulation requirements.

B. Pressure-Independent Control Valves (PICV):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Belimo (PIQCV series up to 3/4-inch and ePIV series for 1-inch and larger)

   b. Bell & Gossett (Ultra Setter series)

   c. Danfoss (AB-QM series)

   d. Flow Control Industries, Inc. (Delta P series)

   e. Griswold (MVP series)

2. Construction:

   a. Mechanical pressure regulation style PIC valves shall have factory installed pressure/temperature test ports (Pete's Plugs) across the pressure regulator at the factory.

   b. Pressure independent control valves 1-inch NPS or larger may use ultrasonic flow measurement. The ultrasonic flow meter will meet the specifications herein.

3. Sizing:

   a. Valve shall be sized for full port at pipe line size for the GPM specified of the device.

   b. Operating Differential Pressure Range: 5 to 50 PSID or better.

   c. The flow through the valve shall not vary more than +/- 5% due to system pressure fluctuations across the valve in the selected operating range. The control valves shall accurately control the flow from 0 to 100% full rated flow.

C. Pressure-Dependent Ball-Style Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Belimo (CCV Series)

   b. Griswold (Unimizer Series)

   c. Honeywell (VB Series)

d. Schneider Electric (VBB/VBS Series)

2. Flow Characteristics: Two-way valves shall have equal percentage characteristics. Three-way valves shall have equal percentage characteristics on A-Port and linear characteristics for B-Port. Bypass applications shall have linear percentage characteristics.

3. Sizing:

a. Two Position (Open/Closed): Line size or size using a 1 psig pressure differential.

b. Two-Way Modulating: Size between 2 and 5 psig pressure differential.

c. Three-Way Modulating: Size between 2 and 5 psig pressure differential.

d. Effective Cv: For any valve smaller than line size, the pressure drop due to the reduction in pipe size shall be taken into effect.

D. Pressure-Dependent Globe-Style Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Belimo

b. Griswold

c. Honeywell

d. Schneider Electric

2. Flow Characteristics: Two-way valves shall have equal percentage characteristics. Three-way valves shall have equal percentage characteristics on A-Port and linear characteristics for B-Port. Bypass applications shall have linear percentage characteristics.

3. Sizing:

a. Two Position (Open/Closed): Line size or size using a 1 psig pressure differential.

b. Two-Way Modulating: Size between 2 and 5 psig pressure differential.

c. Three-Way Modulating: Size between 2 and 5 psig pressure differential.

d. Effective Cv: For any valve smaller than line size, the pressure drop due to the reduction in pipe size shall be taken into effect.

E. Pressure-Dependent Butterfly-Style Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Belimo (HD Series)

b. Honeywell (VFF Series)

c. Schneider Electric (VF Series)

2. Sizing:

a. Two Position (Open/Closed): Line size or size using a 1 psig pressure differential.

b. Two-Way Modulating: Size between 2 and 5 psig pressure differential. Size for the design flow with the disc at 60-degree open position and the design velocity less than 12 FPS.

2.23. ENERGY AND FLOW METERS

A. Refer to Section 239210 for energy and flow meter requirements.

2.24. CONTROL DAMPERS

A. Refer to Section 233300 for control damper requirements.

2.25. ELECTRICAL CONNECTIONS

A. Provide 24V transformers for all control equipment fed by low-voltage (100 to 600 V) power feeders. Coordinate the exact requirements with the Electrical Contractor.

B. Refer to Section 230511 and Division 26 for electrical requirements.

PART 3 - EXECUTION

3.1. GENERAL INSTALLATION

A. Exposed wire nuts, including in plenum, will not be acceptable. All connections will be made inside a rated enclosure.

B. Smoke detectors, high and low limit thermostats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

1. Controlling device (such as motor starters and variable frequency controllers) auxiliary voltage shall remain isolated from relay coil control voltage for safety circuits.

C. Coordinate fire alarm relay connections to the fire alarm system with the fire alarm installer.

D. Verify that duct, pipe, and equipment-mounted devices are installed before proceeding with installation.

E. Install labels and nameplates to identify control components according to Section 230553.

F. Install hydronic instrument wells, valves, and other accessories according to Section 232116.

G. Install refrigerant instrument wells, valves, and other accessories according to Section 232300.

H. Install duct volume-control dampers according to Sections 233113.

I. Install energy and flow meters according to Section 239210.

3.2. SENSOR INSTALLATION

A. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor per ADA requirements. The location(s) to be selected by the Engineer. No sensor shall be mounted until the Engineer gives specific location instructions. Do not install sensor(s) on the inside of exterior building walls (including column fur outs) unless explicitly approved by Engineer.

B. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.

C. Install outdoor air temperature and humidity sensors on north wall at designated location with sun shield.

D. Install mixing plenum sensors in a serpentine manner horizontally (not vertically) across duct. Support each bend with a capillary clip.

E. Install temperature sensors minimum 5-feet downstream of air terminal units.

F. Provide thermowells to Mechanical Contractor for installation. Mechanical Contractor to “stub-up” any thermowell which is too long to install directly into piping. Install heat-conducting fluid in thermowell prior to installing sensor.

G. Install heat-conducting fluid where strap-on temperature sensors contact piping. Clean piping prior to installation. Insulate around sensor.

H. Wall Modules:

1. Limit set point adjustment to plus or minus 3 deg F unless otherwise specified on the Drawings.

2. Wall module shall be programmed such that it can be used for TAB support.

I. Sensor Guards: Install aspirating guards on thermostats in the following locations:

1. Building entrances.

2. Public areas and common spaces.

3. Where indicated.

3.3. PRESSURE SENSOR INSTALLATION

A. Supply (Positive) Duct Static Pressure: Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.

B. Return (Negative) Duct Static Pressure: Pipe low-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.

C. Room Pressure: Pipe appropriate pressure sensor port (positive space: high pressure, negative space: low pressure) to room. Pipe opposite pressure point to reference outside of room. Connect to stainless steel, metal mesh snubber mounted to white 2-inch by 4-inch plate at locations on drawings.

D. Building Static Pressure: Pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building through outside air reference kit. Mount kit per manufacturer’s instructions. Pipe high-pressure port to stainless steel, metal mesh snubber mounted to white 2-inch by 4-inch plate at locations on drawings.

E. Pressure transducers, except those controlling VAV boxes, shall be located in control panels, not on monitored equipment or on ducts. Mount transducers in a vibration-free location accessible for service without use of ladders or special equipment.

F. Mount gauge tees adjacent to air and water differential pressure taps. Install shut-off valves before tee for water gauges.

G. Install differential pressure sensor valve manifolds and eye level, and pipe water from mains down to valve manifold.

3.4. AIR FLOW SWITCHES INSTALLATION

A. Install air flow switches with manufacturers recommended straight duct diameters in horizontal ducts with switch located on the top of the duct.

B. Adjust factory settings to actual field conditions.

C. Install on wet-well fans to indicate ventilation operation or failure.

3.5. CURRENT SWITCHES / TRANSDUCER INSTALLATION

A. Wire may be “wrapped” around CT to obtain better status indication.

B. CTs requiring commissioning/startup will be done per factory installation instructions.

3.6. THERMOSTAT INSTALLATION

A. Install Low-Limit Duct Thermostat (Freezestat, LTD) in ducts and plenums in a serpentine manner horizontally (not vertically) across duct. Support each bend with a capillary clip. The element covers a maximum of 12 inches above and below sensing element. At the bottom of the duct or plenum, the row with the tail end of the sensing element shall be a maximum of 6 inches from the bottom.

3.7. RELAY INSTALLATION

A. Relays will be mounted at a location where pilot light is visible from floor.

3.8. ACTUATOR INSTALLATION

A. Wire parallel actuators according to manufacturer's recommendations.

B. Check operation of valve/damper-actuator combination to confirm that actuator modulates valve/damper smoothly throughout stroke to both open and closed positions. Check valve for proper close-off.

C. Damper Actuators:

1. Install automatic dampers according to Section 233300.

2. Mount actuators directly on damper shaft or jackshaft unless shown as a linkage installation.

3. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5 degrees in the open position, manually close the damper, and then tighten linkage.

4. Provide necessary mounting hardware and linkages for actuator installation.

5. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures. Provide access door per specifications for any actuator inside of ductwork.

D. Valve Actuators: Connect actuators to valves with adapters approved by actuator manufacturer.

3.9. VALVE INSTALLATION

A. Refer to the Control Valve Application Schedule at end of section.

B. Where not provided from the factory, install pressure/temperature test ports (Pete’s Plugs) for testing of pressure differential across the PIC valve.

C. For pressure independent control valves with electronic flow metering, coordinate with mechanical contractor to ensure 5 pipe diameters of straight pipe entering valve.

3.10. CONTROL VALVE APPLICATIONS

A. Provide control valve types listed in the Control Valve Application Schedule below, unless otherwise noted on plans, details, diagrams or equipment schedules.

CONTROL VALVE APPLICATION SCHEDULE

	SERVICE	CONFIGURATION	PIPE SIZES	VALVE TYPE	
HYDRONIC	HEATING COILS	2-WAY 2-POSITION	2-INCHES AND SMALLER	PD	BALL
			2 1/2-INCHES AND LARGER	PD	BUTTERFLY
		2-WAY MODULATING	2-INCHES AND SMALLER	PI	BALL
			2 1/2-INCHES AND LARGER	PI	BALL / GLOBE
	COOLING COILS	2-WAY 2-POSITION	2-INCHES AND SMALLER	PD	BALL
			2 1/2-INCHES AND LARGER	PD	BUTTERFLY
		2-WAY MODULATING	2-INCHES AND SMALLER	PI	BALL
			2 1/2-INCHES AND LARGER	PI	BALL / GLOBE
		3-WAY MODULATING	2-INCHES AND SMALLER	PD	BALL
			2 1/2-INCHES AND LARGER	PD	BALL / GLOBE
	HYDRONIC LOOP BYPASS	2-WAY MODULATING	2-INCHES AND SMALLER	PD	BALL
			2 1/2-INCHES AND LARGER	PD	BALL / GLOBE
	EQUIPMENT BYPASS	2-WAY 2-POSITION	2-INCHES AND SMALLER	PD	BALL
			2 1/2-INCHES AND LARGER	PD	BUTTERFLY
		3-WAY 2-POSITION	2-INCHES AND SMALLER	PD	BALL
			2 1/2-INCHES AND LARGER	PD	BALL / GLOBE
	ISOLATION VALVES	2-WAY 2-POSITION	2-INCHES AND SMALLER	PD	BALL
			2 1/2-INCHES AND LARGER	PD	BUTTERFLY

NOTES:

1. COIL AND EQUIPMENT WITH PRESSURE DEPENDENT CONTROL VALVES REQUIRE BALANCING VALVES. REFER TO 232119.
2. COIL AND EQUIPMENT WITH PRESSURE INDEPENDENT CONTROL VALVES DO NOT REQUIRE BALANCING VALVES.

END OF SECTION 239010

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SECTION 239020 – BAS FIELD CONTROLLERS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes BAS field controllers.

1.2. DESCRIPTION

A. Field Controllers are defined as any intelligent device, provided under any specification Division, by any contractor, which communicates with other Field Controllers or a Network Controller in an intelligent manner, beyond a simple contact closure or analog signal.

B. Clarifications:

C. Field Controllers shall communicate utilizing the following protocol(s):

1. LonTalk, in accordance with the latest ANSI Standard ANSI/CEA 709.1.

2. BACnet, in accordance with the latest ASHRAE Standard 135.

D. Other protocol communication, such as Modbus, shall be acceptable when specifically requested for engineering approval.

E. Field Controllers shall fundamentally communicate via the protocol(s) listed. Field Controllers which communicate over a non-specified protocol and then convert to a specified protocol via a protocol converter, router or gateway are not acceptable.

1.3. SUBMITTALS

A. Comply with the requirements of Section 239000.

1.4. QUALITY ASSURANCE

A. Comply with BAS general requirements in Section 239000.

B. BACnet Controller Requirements: Certify that the controllers proposed to be provided meet each one of the following requirements:

1. Provide BACnet Controllers that BACnet Testing Laboratory listed (v12 or later) as specified herein:

a. BACnet Building Controller (B-BC)

b. BACnet Advanced Application Controller (B-AAC)

c. BACnet Application Specific Controller (B-ASC)

2. All BACnet Controllers shall use the following communication specifications and achieve performance as specified herein:

a. All controllers shall be able to communicate peer-to-peer without the need for a Network Control Unit (NCU). Any controller on the MS/TP Data Link/Physical layer shall be able to act as a Master to allow for the exchange and sharing of data variables and messages with any other controller connected on the same communication cabling. Sub-controllers (aka "slave" controllers) are not acceptable.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

A. Comply with the requirements of Section 239000.

2.2. DDC CONTROLLERS

A. General Requirements

1. DDC Controllers shall be provided for AHUs, Chillers, Boilers, Water Systems, Blower Coils, Heat Pumps, Variable Air Volume (VAV) Terminals and other applications as needed.

2. The application control program for each controller shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals.

3. All control sequences programmed into the controller shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.

a. Controller shall be able to return to full normal operation without user intervention after a power failure of unlimited duration.

4. Controller shall be 32 bit microprocessor-based. They shall also be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules.

5. Controller size shall be sufficient to fully meet the requirements of this specification and the sequence of operations.

6. Each TCU shall have sufficient memory, to support its own operating system and databases, including: control processes, maintenance support applications, custom processes, and manual override monitoring.

7. Each controller shall support monitoring of the following types of inputs and outputs, without the addition of equipment outside the Controller enclosure:

a. Digital inputs from dry contact closure, pulse accumulators, voltage sensing.

b. Analog inputs of 4-20 mA, 0-10 Vdc, thermistor and RTD in the range 0 to 350,000 ohm.

c. Digital outputs of 24 Vac/dc (contact closure).

d. Analog outputs of 4-20 mA and 0-10 Vdc.

8. Controller analog or universal input shall use a 16 bit A/D converter. Controllers with less than 16 bit A/D converters must provide all analog input sensors with 4-20ma transmitters.

9. Controller analog or universal output shall use a 10 bit D/A converter.

10. Each controller shall have a minimum of 10% spare capacity for each point type for future point connection.

    a. Provide all processors, power supplies and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

    b. As a minimum, provide one of each type of point available on the controller.

11. Controllers shall function normally under ambient conditions of 32 to 120 deg F and 5 to 90 percent RH (non-condensing).

12. Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

13. Each controller shall perform its primary control function independent of other NCU controller LAN communication, or if LAN communication is interrupted.

    a. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable.

14. The controller shall receive its real-time data from the NCU controller time clock to ensure LAN continuity.

15. Each controller shall include algorithms incorporating proportional, integral, and derivative (PID) gains for all applications.

    a. All PID gains and biases shall be field-adjustable by the user via terminals as specified herein.

B. Local Control Units (LCU): For primary systems (including but not limited to AHU, MAU, chiller, boiler, and water systems.)

1. Controller shall be fully programmable, and the programming software shall have a library of pre-built, tested, and user re-definable control sequences for a wide range of typical HVAC applications.

2. Each LCU shall have sufficient memory to support any required energy management applications or alarm management applications.

3. Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.

4. LCU shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components.

5. Should the LCU memory be lost for any reason, the user shall have the capability of reloading the controller software via the BAS LAN operator workstation or server.

6. Provide an onboard network communication jack for connection to the network (RJ-45 or equivalent quick connect)

C. Terminal Control Units (TCU): For secondary systems (including but not limited to VAV, fan-powered VAV, fan coil, radiation, and reheat coils.)

1. Where a TCU is deemed to have insufficient capability for the application, whether due to memory, power, I/O, etc., the Contractor will provide an appropriate LCU in lieu of a TCU.

2. TCU shall be powered from a 24 Vac source.

3. TCU shall be fully programmable, and the programming software shall have a library of pre-built, tested, and user re-definable control sequences for a wide range of typical HVAC applications.

   a. Operating programs shall be field selectable for specific applications.

   b. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility.

   c. TCU that require factory changes of all applications are not acceptable.

4. TCU which is provided with on-board sensors or devices, such as pressure sensors or actuators, will meet the requirements as set forth in 239010. Where sensors or devices do not meet those requirements, a those sensors or devices will be provided separately.

D. Configurable Terminal Control Units (CTCU): For secondary systems (including but not limited to VAV, fan-powered VAV, fan coil, radiation, and reheat coils.)

1. CTCU will meet all the requirements set forth in the TCU section above, as well as the additional requirements below:

2. CTCU may be provided so long as they can be configured “out-of-the-box” to meet the sequences of operation on the drawings. Configurations which require special programming beyond the factory configuration options are not acceptable, and an LCU or TCU will be provided instead.

3. Provide documentation in submittals where CTCUs are proposed to show configuration details and how they will meet the sequence.

2.3. ANALOG CONTROLLERS

A. Step Controllers: 6 or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.

B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F, and single- or double-pole contacts.

C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.

D. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.

PART 3 - EXECUTION

3.1. FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.

2. Test and adjust controls and safeties.

3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.

4. Test each point through its full operating range to verify that safety and operating control set points are as required.

5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.

6. Test each system for compliance with sequence of operation.

7. Test software and hardware interlocks.

B. BAS Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.

2. Comply with verification requirements of Section 239000.

C. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.2. ADJUSTING

A. Comply with adjustment requirements of Section 239000.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of project completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to six visits to Project during other than normal occupancy hours for this purpose.

END OF SECTION 239020

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SECTION 239030 – BAS NETWORK LEVEL CONTROLS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes BAS network level controls.

1.2. DESCRIPTION OF WORK

A. Network Level Controls are defined as any device which aggregates data, either via hardwired or wireless, from one or more Field Controllers. Most commonly they are at the building level, defined as a Network Control Unit (NCU) herein, and communicate with various piece of mechanical equipment. Network Level Controls might also aggregate data from lower-Network Level Controls to a higher-Network Level Controls, such as from a building level to a campus or enterprise level. Network Level Controls are typically where the operator interface resides. Network Level Controls could refer to an application-specific piece of hardware provide by the overall BAS System Manufacturer, or to software which resides on a Windows-based PC or server.

1.3. SUBMITTALS

A. Comply with the requirements of Section 239000.

1.4. QUALITY ASSURANCE

A. Comply with BAS general requirements in Section 239000.

B. In addition to the Quality Assurance requirements set forth in 239000 the following shall be required:

1. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this project.

2. Tridium Niagara Certification or Approved Equivalent: The system programmer(s) shall have successfully completed the associated certification training courses related to the applicable versions of software.

PART 2 - PRODUCTS

2.1. GENERAL REQUIREMENTS

A. Description: DDC system, having all points exposed to network, and Tridium Niagara 4 or AX integration software framework or approved equivalent. The control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories and software connected to distributed controllers operating in multiuser, multitasking environment on ethernet or token-passing networks and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics. The control system shall be complete and fully operable.

B. Tridium Niagara Licenses: All Niagara based systems shall have “open” licenses. The Niagara Compatibility Statement (NICS) for all Niagara Software shall allow open access and be set as follows: accept.station.in="*" accept.station.out="*" accept.wb.out="*" accept.wb.in="*”. The system shall not prevent another vendor from accessing and modifying the software with the proper admin login. Proprietary software shall not be required for future vendors to integrate with this system. No proprietary JAR (Java ARchive) files or other drivers shall be used on the JACE hardware. If any hardware or software must be modified, repaired, or replaced in the future, any qualified vendor shall be able to do so without the support of this system’s vendor.

C. Software and Equipment Licenses: All systems shall be “open”. Issue a copy of all software and licensing information to the owner such that the Owner will own all licensing and project software. All configuration tools and programs necessary to configure the Owner’s system, including the project specific data base, graphics and application programming code shall be provided to the Owner.

D. Coordinate with owner on specific version of Niagara to be installed.

2.2. OPEN ARCHITECTURE

A. DDC system shall provide an open, interoperable and integrated architecture with a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate BACnet/IP, BACnet MS/TP, LonWorks, Modbus IP, Modbus RTU, Modbus TCP, Niagara 4, AX and R2 and proprietary legacy communication protocols in a single interoperable system. The system shall be accessible by web browsers with secured access.

B. Control System Server: Structural Query Language (SQL) using Open Database Connectivity (ODBC) compliant server database stored on a server. Systems requiring a proprietary database and/or user interface programs must be submitted for approval.

2.3. NETWORKS

A. Virtual Local Area Network (VLAN): The minimum 100 Mbps Ethernet VLAN shall connect a local control system server, operator workstation and multiple Network Control Units (.i.e., Java Application Control Engines JACEs or Approved Equivalent). The VLAN shall support XML internet protocol, Hypertext Transfer Protocol (HTTP), Simple Object Access Protocol (SOAP), Java, BACnet and LonWorks.

B. Local Area Network (LAN): The minimum 100 Mbps Ethernet LAN shall comply with IEEE Standard 802.3 and use 100 Base-TX, UTP-8 wire, Category 6 (Cat 6) cabling.

C. Remote Access: The VLAN shall be accessible without proprietary software by commonly available web browsers (i.e. Microsoft Internet Explorer, Google Chrome, Mozilla Firefox and Apple Safari) with tiered username and password security access.

1. Internet Access: The Owner shall provide high-speed internet connection for access to the VLAN. The Owner shall provide temporary secured access, for the duration of the project through the one-year walk-through, to the VLAN users.

2. Graphics: The web browser view of the graphics shall be the same as provided by the Operator Interface Graphic Software when accessed directly on the Owner's network. The web browser graphics shall support URL hypertext links for other locations on the internet and intranet.

2.4. NETWORK LEVEL CONTROLS HARDWARE

A. Microsoft Windows Based Hardware: Refer to Section 239040.

B. Network Control Unit (NCU):

1. Network Control Unit (NCU) will be a JACE 9000 or Approved Equivalent provided by manufacturers listed in 239000.

2. Each NCU shall have sufficient memory, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified.

3. The communication protocols utilized for peer-to-peer communications between NCUs and/or Supervisors will be firstly Niagara N4 FOX and FOXS, secondarily BACnet TCP/IP (when N4 communication is not available) and lastly SNMP. Use of a proprietary communication protocol for peer-to-peer communications between NCUs and/or Supervisors is not allowed.

2.5. NIAGARA FRAMEWORK (OR APPROVED EQUIVALENT) WEB SUPERVISOR

A. Where multiple NCUs are to be installed, a Web Supervisor will be installed to integrate the multiple NCUs.

PART 3 - EXECUTION

3.1. INSTALLATION

A. Install NCUs in a control panel at locations on the drawings. Coordinate data drops and control panel requirements as per 239000.

B. Install Supervisor software at location at the highest-Network Level Controls, unless otherwise specified.

C. Operator Interface will reside at the Supervisor location, unless otherwise specified.

END OF SECTION 239030

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SECTION 239040 – BAS FRONT-END SOFTWARE AND HARDWARE

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes BAS control system front-end software and hardware.

1.2. SUBMITTALS

A. Comply with the requirements of Section 239000.

1.3. QUALITY ASSURANCE

A. Comply with BAS general requirements in Section 239000.

B. System Performance: The system shall comply with the following minimum performance requirements:

1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.

2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.

3. Object Command: Reaction time of less than 2 seconds between operator command of a binary object and device reaction.

4. Object Scan: Transmit change of state and change of analog values to control units or workstation within 6 seconds.

5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.

PART 2 - PRODUCTS

2.1. DDC SOFTWARE

A. General Requirements:

1. Alarm processing, messages, and reactions.

2. Trend logs retrievable in spreadsheets and database programs.

3. Alarm and event processing.

4. Object and property status and control.

5. Automatic restart of field equipment on restoration of power.

6. Data collection, reports, and logs. Include standard reports for the following:

a. Current values of all objects.

b. Current alarm summary.

c. Disabled objects.

d. Alarm lockout objects.

e. Logs.

7. Custom report development.

8. Utility and weather reports.

9. Workstation application editors for controllers and schedules.

10. Maintenance management.

B. Custom Application Software:

1. English language oriented.

2. Full-screen character editor/programming environment.

3. Allow development of independently executing program modules with debugging/simulation capability.

4. Support conditional statements.

5. Support floating-point arithmetic with mathematic functions.

6. Contains predefined time variables.

C. Archiving: Automatically store data base back-up and trend data at one operator workstation and the server without operator action. Operator shall be able to manually download entire controller databases or parts thereof.

2.2. OPERATOR INTERFACE GRAPHIC SOFTWARE

A. General Requirements:

1. Graphic software shall provide user-friendly and intuitive operation of the systems with minimal training and experience at each level of interface, including operator workstations, diagnostic terminal units, and mobile applications. It shall allow multi-tasking for third-party software and alarm graphics to display when in other software windows.

2. Dynamic Data Displays: Automatically update point values at a minimum frequency of every 10 seconds or less. Data point displays shall be color-coded and indicate normal, abnormal, alarm, signal loss and override conditions.

3. Override Function: Graphic software shall allow an override for each digital data point value and for each change in analog status. The override value shall reside in the equipment controller not just at the OWS.

a. Password Protection: Provide password protection for each level of importance as determined with the Owner.

b. Override Tracking: Each override shall be tagged with the associated operator’s identification number, name or initials.

2.3. MICROSOFT WINDOWS BASED HARDWARE

A. BAS Server or Building Supervisor: One (1) PC-based microcomputer(s) manufactured by Dell, Lenovo or Hewlett Packard or approved equivalent.

1. Motherboard: With 2 integrated USB 3.0 ports, 2 integrated USB 2.0 ports, integrated Intel Pro 10/100/1000 Ethernet card, integrated audio, bios and hardware monitoring.
2. Processor: Intel Core i7, Quad (4)-core, 3.40 GHz.
3. Random-Access Memory (RAM): 12 GB, DDR4 SDRAM
4. Graphics: Video adapter, minimum 1600 x 1200 pixels, 3 GB video memory.
5. Hard-Disk Drive: 2.0 TB SATA with 6 GB/s transfer rate.
6. CD-ROM Read/Write Drive: 48x24x48.
7. Monitor: 27-inch flat-panel LED color monitor with 1920x1080 resolution, 120 Hz refresh rate and HDMI, VGA and DVI-D inputs.
8. Keyboard: QWERTY, 105 keys in ergonomic shape, wired.
9. Mouse: Three button, optical, wired.
10. Uninterruptible Power Supply: 2 kVa.
11. Operating System: Microsoft Windows Server 2019, Windows 10 64-bit with the most recent service packs and system updates.
12. The server shall support all Network Control Units (NCU), operator workstations, and 3rd party mechanical / electrical systems connected to the Facility Management Building Automation System (BAS) Local Area Network (LAN).
13. Antivirus Software: 3-year Symantec (or equal by Owner request) subscription service of antivirus software.
14. Location: DATA ROOM E102

B. Diagnostic Terminal Unit (DTU) if System is Standalone (i.e., not required if customer facility management has laptop for access): One (1) portable notebook-style, PC-based microcomputer terminal manufactured by Dell, Lenovo or Hewlett Packard.

1. Motherboard: With 2 integrated USB 3.0 ports, 2 integrated USB 2.0 ports, integrated Intel Pro 10/100/1000 Ethernet card, integrated audio, bios, and hardware monitoring.
2. Processor: Intel Core i7, Quad (4)-core, 2.80 GHz.
3. Random-Access Memory (RAM): 8 GB, DDR3L SDRAM
4. Graphics: Video adapter, minimum 1600 x 1200 pixels, 2 GB video memory.
5. Monitor: 17-inch LED color.
6. Keyboard: QWERTY 105 keys.
7. Hard-Disk Drive: 1.0 TB SATA with 6 GB/s transfer rate.
8. CD-ROM Read/Write Drive: 48x24x48.
9. Pointing Device: Touch pad or other internal device.
10. Operating System: Microsoft Windows 10 64-bit with the most recent service packs and system updates.
11. Antivirus Software: 3-year Symantec (or equal by Owner request) subscription service of antivirus software.

PART 3 - EXECUTION

3.1. WORKSTATION INSTALLATION

A. Portable Workstations Installation:

1. Turn over portable workstations to Owner at project completion.

2. Install software on workstation(s) and verify software functions properly.

B. SERVER INSTALLATION

1. Install number of servers required to suit requirements indicated. Review project requirements and indicate layout of proposed location in submittals.

2. Install software indicated on server(s) and verify that software functions properly.

3. Power servers through dedicated UPS unit. Locate UPS adjacent to server.

END OF SECTION 239040

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SECTION 239210 – ENERGY AND FLOW METERS

PART 1 - GENERAL

1.1. SUMMARY

A. Section includes BAS energy and flow meters for piping and duct systems.

1.2. SUBMITTALS

A. Product Data: Provide data for product indicating compliance with the requirements of this project.

1. Wiring Diagrams: Power, signal and control wiring.

B. Close-Out Submittals:

1. Operation and Maintenance Data: For energy and flow meters to include in operation and maintenance manuals.

1.3. QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 by a qualified testing agency accepted by the Authority Having Jurisdiction and marked for intended location and application.

1. Listing agencies of electrical and mechanical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

1.4. WARRANTY

A. Warranty: Provide two-year manufacturer’s parts and labor warranty for each energy and flow meter.

PART 2 - PRODUCTS

2.1. AIR FLOW MEASURING STATIONS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Air Monitor Corporation
2. Ebtron
3. Paragon Controls
4. Tek-Air Systems

B. Duct Air Flow Measuring Stations, Thermal Dispersion Type: Type 304 or 316 stainless steel sensing elements with multiple ports, 24Vac power and 4 to 20 mA signal. The sensing element shall be specifically designed to measure air flow in duct. Ebtron (Gold Series, Duct and Plenum) or equal.

1. Accuracy: Plus or minus 3 percent at 100 to 5,000 fpm.
2. Operating Conditions, Air Stream: Minus 20 to plus 140 deg F and 0 to 99 percent humidity, non-condensing.
3. Pressure Drop: 0.20-inches wg at 4,000 fpm maximum.
4. Noise Generation: NC-40 maximum, self-generated sound level.

C. Fan Inlet Air Flow Measuring Stations, Thermal Dispersion Type: Type 304 or 316 stainless steel sensing elements with multiple ports, 24Vac power and 4 to 20 mA signal. The sensing element shall be specifically designed to measure air flow of a centrifugal fan at the inlet cone. For double-inlet fans, provide one set of elements for each inlet. Ebtron (Gold Series, Fan Inlet) or equal.

1. Accuracy: Plus or minus 2 percent at 100 to 5,000 fpm.
2. Operating Conditions, Air Stream: 32 to 140 deg F and 0 to 99 percent humidity, non-condensing.
3. Pressure Drop: 0.20-inches wg at 4,000 fpm maximum.
4. Noise Generation: NC-40 maximum, self-generated sound level.

D. Transmitter: Heavy-duty construction with LED display with 4 to 20 mA air flow and temperature output signals and BACnet MS/TP RS-485 output for interface with the building automation system (BAS).

2.2. FLOW AND THERMAL ENERGY METERS

A. Thermal Mass Natural Gas Flow Meters, Insertion Type: Insertion thermal mass flow meter suitable for natural and propane gas with Type 316 stainless steel wetted metal components and flow conditioner. Meter shall be able to be inserted and removed by hand without system shutdown. Onicon F-5000 Series or equal.

1. Pressure Rating: 500 psig.
2. Medium Temperature Rating: 150 deg F.
3. Operating Range: 100:1
4. Output Signals: 4-20 mA (flow rate) and pulse (totalization).
5. Accuracy: +/- 1.0 percent of surface feet/minute with 500 to 7000 reading.
6. Control Interface: BACnet IP.

B. Compound Hydronic Flow Meters, In-Line Type (NPS 2 to 6-inches): Inline compound-flow meter with turbine and low flow disc measuring elements designed for wide range of water flow measuring, lead-free copper alloy body, cast-iron flanges, two direct-reading magnetic-driven roll-sealed registers and complies with AWWA C702. Neptune TRU/FLO series or equal.

1. Pressure Rating: 150 psig.
2. Medium Temperature Rating: 80 deg F.
3. Operating Range: 1000:1
4. Output Signals: 4-20 mA (flow rate) and pulse (totalization).
5. Accuracy: +/- 1.5 percent of volume.
6. Control Interface: BACnet IP.

2.3. ELECTRICAL CONNECTIONS

A. Provide 24V transformers for all control equipment fed by low-voltage (100 to 600 V) power feeders. Coordinate the exact requirements with the Electrical Contractor.

B. Comply with the requirements of Section 230511 and Division 26.

PART 3 - EXECUTION

3.1. INSTALLATION

A. Install labels and nameplates to identify control components according to Section 230553.

B. Install hydronic instrument wells, valves, and other accessories according to Section 232116.

3.2. AIR FLOW MEASURING STATION INSTALLATION

A. Install air flow measuring stations in locations indicated and required to perform the sequences of operation. Install stations in accordance to the manufacturer's recommendations.

1. Do not install air flow measuring station sensors and probes until all sanding and grinding activities are complete to protect them from accumulating dust and debris.

2. Coordinate with duct installer to provide minimum 12/12 duct access door where probe sensors are not easily accessible for maintenance to clean. Install multiple for ducts over 48" wide.

3.3. FLOW AND ENERGY METER APPLICATION

A. Flow Meters for Piping Systems:

1. Natural Gas: Thermal Mass.

2. Domestic Water (2 to 6 inches NPS): Compound.

3.4. FLOW AND ENERGY METER INSTALLATION

A. Assemble and install connections, tubing, and accessories between flow-measuring elements and flow meters according to manufacturer's written instructions.

B. Install flow meter elements in accessible positions in piping systems.

C. Install wafer-orifice flow meter elements between pipe flanges.

D. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

E. Install grounding rings on the inlet and outlet side of each electromagnetic style meter when installed in non-metallic or lined piping. Grounding ring dimensions, spacing and wiring shall meet manufacturer’s recommendations.

F. Install flow and energy meters as recommended by the manufacturer and as follows, whichever is stricter:

1. Thermal Mass, Insertion Type: Straight pipe length shall be minimum 10 times the pipe diameter on the inlet and 5 times on the outlet.

2. Compound, In-Line Type: Per manufacturer.

3.5. CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

1. Connect flow meter-system elements to meters.

2. Connect flow meter transmitters to meters.

3. Connect thermal-energy meter transmitters to meters.

3.6. ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Extend 120V power circuits from points provided to control voltage transformers. Where dedicated junction boxes have been provided, coordinate the exact locations with the Electrical Contractor. Where they have not, coordinate the spare circuit breakers to be used with the Electrical Contractor or Owner.

B. Install raceways, boxes, and cabinets according to Section 230511 and Division 26.

C. Install building wire and cable according to Section 230511 and Division 26.

D. Install signal and communication cable according to Section 230511 and Division 26. Comply with manufacturer's installation guidelines.

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.

2. Install exposed cable in raceway.

3. Install concealed cable in raceway.

4. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.

5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.

6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.

7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

E. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

F. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.7. ADJUSTING

A. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90 and 100 percent of span.

B. Manually operate flow switches to verify that they make or break contact.

C. After installation, calibrate meters according to manufacturer's written instructions.

D. Adjust faces of meters to proper angle for best visibility.

END OF SECTION 239210

SECTION 260100 – BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.

B. All sections of Division 26 are interrelated. Where materials are required to complete work associated with equipment in a specific section, but the materials are not specified within that specific section, the requirements for those materials shall be as specified elsewhere in Division 26.

1.2 SUMMARY

A. This Section includes general administrative and procedural requirements for electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 01:
   1. Submittals.
   2. Coordination drawings.
   3. Fault Current, Device Coordination, & Arc Flash Report
   4. Record documents.
   5. Maintenance manuals.
   6. Rough-ins.
   7. Electrical installations.
   8. Cutting and patching.
   9. Inspections

B. Related Sections: The following sections contain requirements that relate to this section:
   1. Division 26 Section "Basic Electrical Materials and Methods," for materials and methods common to the remainder of Division 26.

1.3 SUBMITTALS

A. General: Follow the procedures specified in Division 01 Section "Submittal Procedures".

B. Specific Requirements to Electrical Product Data and Shop Drawing Submittals:
   1. Submit newly prepared information, drawn to scale where applicable. Do not reproduce Contract Documents or use Contract Document images in the preparation of submittals.
   2. Any deviations from Contract Documents shall be clearly noted and highlighted, encircled, or otherwise visually identified.
   3. Product Data and Shop Drawings are separate items and shall be submitted with separate submittal numbers. Where both Product Data and Shop Drawings are required by the same specification section (i.e. Fire alarm) both items shall be submitted for review at the same time. Product Data and Shop Drawings will be reviewed separately by Engineer, but Engineer reserves the right to withhold review until both items have been received.
   4. Submittal Documents Quality: Facsimile documents are prohibited. Submittals containing sheets copied from facsimile documents will be automatically Rejected and returned to Contractor without review. Also submittals containing poor quality copies will be automatically Rejected and returned to Contractor without review.
   5. Submittal Document Binding: Use report covers with 3-hole, dual-prong tang fasteners or slide fasteners. Velo- and comb bound documents are also acceptable. Use of 3-ring binders is prohibited and will be automatically rejected and returned to Contractor without review.

C. Additional copies may be required by individual sections of these Specifications.

D. Substitution of Equivalent Products: Where individual sections require submittal for substitution of manufacturers and products equivalent to those listed under Manufacturers paragraph, submittals shall be in accordance with that section. Engineer has final authority on equivalence and acceptance.
   1. Submittal of Substitution Request Forms are permitted by Prime Bidders only. Substitution Request Forms submitted by a vendor, distributor, or sub-contractor will not be accepted or reviewed.

1.4 RECORD DOCUMENTS

A. Prepare record documents in accordance with the requirements in Division 01 Section "Closeout Procedures." In addition to the requirements specified in Division 01, indicate installed conditions for:
   1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
   2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
   3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.5 OPERATION & MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 01 Section "Closeout Procedures" In addition to the requirements specified in Division 01, include the following information for equipment items:
   1. Product data for all equipment installed during construction. Product data shall be manufacturer literature, cut-sheets, and/or catalogs and shall clearly depict manufacturer and model number along with standard features and optional features where applicable.
   2. Where available for installed equipment, Contractor shall include manufacturer’s published Installation and/or Owner’s manuals.
   3. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
   4. Programming report/summary for all systems with conditional logic programming (i.e. fire alarm, lighting control system, and PLCs)
   5. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
   6. Warranty Information: Copies of documentation for all additional and secondary warranties shall be included.

1.6 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.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 ROUGH-IN

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

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

3.2 ELECTRICAL INSTALLATIONS

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

B. Basis of Design: Where specific systems and products are shown or specified with a Basis of Design, the supporting work and appurtenances are shown and specified uniquely for the Basis of Design. Where systems and products other than the Basis of Design are installed, Contractor shall adjust circuiting, raceway infrastructure, cable type, wire size, supporting means, backbox type, and any other appurtenance as required for a complete, fully functional and operational system or product.

3.3 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with the following requirements:
   1. Perform cutting, fitting, and patching of electrical equipment and materials required to:
      a. Remove and replace defective Work.
      b. Remove and replace Work not conforming to requirements of the Contract Documents.
      c. Upon written instructions from the Engineer, uncover and restore Work to provide for Engineer observation of concealed Work.
   2. Cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work.
   3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
   4. Protection of Installed Work: During cutting and patching operations, protect adjacent installations. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

5. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

3.4 INSPECTIONS

A. Authority Having Jurisdiction: Notify and schedule all inspections, with a minimum 10 day notice in writing prior, to the Authority Having Jurisdiction.

END OF SECTION 26 01 00

SECTION 260500 – BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Electrical Equipment Installation.
2. Sleeves and sleeve seals for raceway and cable.
3. Firestopping.
4. Concrete equipment bases.
5. Cutting and patching for electrical construction.
6. Touchup painting.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.4 COORDINATION

A. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.

1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.

B. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in rooms.

C. Coordinate electrical service connections to components furnished by utility companies.

1. Coordinate installation and connection of exterior underground and overhead utilities and services, including provision for electricity-metering components.
2. Comply with requirements of authorities having jurisdiction and of utility company providing electrical power and other services.

D. Coordinate location of access panels and doors for electrical items that are concealed by finished surfaces.

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 CONCRETE BASES

A. Concrete Forms and Reinforcement Materials: As specified in Division 03 Section "Cast-in-Place Concrete."

B. Concrete: 3000-psi (20.7-MPa), 28-day compressive strength as specified in Division 03 Section "Cast-in-Place Concrete."

2.3 TOUCHUP PAINT

A. For Equipment: Equipment manufacturer's paint selected to match installed equipment finish.

B. Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

PART 3 - EXECUTION

3.1 ELECTRICAL EQUIPMENT INSTALLATION

A. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide the maximum possible headroom.

B. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.

C. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations. Provide any additional supporting means not provided by manufacturer to install equipment.

D. Right of Way: Give to raceways and piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, or cable trays, penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Sleeves for power raceway and cables: Steel, cut sleeves to length for mounting flush with both surfaces of walls.

F. Sleeves for telecommunication cables: Rigid galvanized steel conduit, extend sleeves 2” on each side of wall. Provide plastic bushing on each end.

G. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.

H. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.

I. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants.".

K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

L. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

M. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

N. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.4 FIRESTOPPING

A. Apply firestopping to cable and raceway penetrations of fire-rated floor and wall assemblies to achieve fire-resistance rating of the assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.5 CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger, in both directions, than supported unit. Follow supported equipment manufacturer's anchorage recommendations and setting templates for anchor-bolt and tie locations, unless otherwise indicated. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

3.6 CUTTING AND PATCHING

A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.

B. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fireproofing where existing firestopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

3.7 REFINISHING AND TOUCHUP PAINTING

A. Refinish and touch up paint. Paint materials and application requirements are specified in Division 09 Section “Interior Painting” and Division 09 Section “Exterior Painting”

1. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit the degree of damage at each location.
2. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.
3. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
4. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.8 CLEANING AND PROTECTION

A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.

B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

END OF SECTION 26 05 00

SECTION 260519 – CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Field quality-control test reports: Submit all cable tests reports to Engineer ten days prior to Final Inspection.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. American Insulated Wire Corp.; a Leviton Company.
2. General Cable Corporation.
3. Southwire Company.

B. Conductors: Comply with NEMA WC 70.

C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN and XHHW.

2.2 CONNECTORS AND SPLICES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Thomas & Betts Corporation.
2. Ideal Industries, Inc.

3. 3M; Electrical Products Division.
4. Tyco Electronics Corp.

B. Description: UL listed, factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated. Splices in solid conductors for branch circuits shall be made using Ideal Wirenuts, 3M Scotchlocks, or T&B Marrette pressure type wire connectors. Permanent crimp connectors are not acceptable.

1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger. Refer to feeder schedule on riser for location of copper feeders.

B. Feeders: Aluminum compact stranded. Stranded for No. 1 AWG (100amp) and larger. Refer to feeder schedule on riser for location of aluminum feeders.

C. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
1. Where final connections to equipment are in flexible conduit, all conductors shall be stranded type (regardless of size).

D. Minimum Size: No. 12 AWG for power and lighting circuits.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-THWN or XHHW, single conductors in raceway.

B. Exposed Feeders: Type THHN-THWN or XHHW, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN or XHHW, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN or XHHW, single conductors in raceway.

E. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-THWN or XHHW, single conductors in raceway.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN or XHHW, single conductors in raceway.
1. Concealed Lighting Branch Circuits: Type MC cable, #12 AWG, copper conductor, 90°C insulation. May be used for connecting light fixtures together. Maximum length is 15'. All home runs to first light fixture and switch legs shall be in conduit. Do not use for receptacle or other power circuits.

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN or XHHW, single conductors in raceway.

H. Fire Alarm Circuits: See Section "Fire Alarm", in raceway.

I. Class 1 Control Circuits: Type THHN-THWN or XHHW, in raceway.

J. Class 2 Control Circuits: Type THHN-THWN or XHHW, single conductors in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Voltage Drop: Conductor size shall be increased to account for voltage drop as follows:

1. Where the conductor length from the panel to the first outlet on a 277V circuit exceeds 125 feet, the branch circuit conductors from the panel to the first outlet shall not be smaller than #10 AWG.
2. Where the conductor length from the panel to the first outlet on a 120V circuit exceeds 50 feet, the branch circuit conductors from the panel to the first outlet shall not be smaller than #10 AWG. Increase an additional wire size for every additional 50’ to first outlet.

F. Dedicated Neutrals: Provide dedicated neutral for all single-pole branch circuits, unless otherwise noted on plans.

G. Support cables according to Division 26 Section "Hangers and Supports."

H. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

3.4 CONNECTIONS

A. Keep conductor splices to a minimum. No feeders shall be spliced. No splicing shall be made except within outlet or junction boxes, troughs, or gutters.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Splices shall be made using with pre-insulated spring/coil connectors (wire nuts), insulated barrel mechanical lugs, or box mounted insulated terminal strips.
2. Push-in type, permanent crimp-on type, and split-bolt type are prohibited.
3. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Testing Technician

1. The testing technicians shall be trained in all the methods of correctly and safely conducting the required test. The technician shall have regular experience conducting the required tests and they must have the knowledge to determine the serviceability of a specific piece of equipment.

C. Tests and Inspections: After installing conductors and cables and before electrical circuitry has been energized, test conductors for compliance with following requirements.

1. Physical Inspection and Testing

a. Verify cable ratings and data correspond to drawings and specifications.
b. Verify electrical connections are made to provide the electrical system described in the drawings and specifications.
c. Confirm bolted electrical connections are provided with high impedance using one of the following means:

1) Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar connections. Any similar resistance values that deviate more than 50 percent should be investigated.
2) Inspect the bolted connection and verify that it is at the manufacturer's rated torque using a calibrated torque wrench.

d. A thermographic test of the service entrance conductors and distribution feeders. Conductor connection points shall be visible during the test. All equipment should be energized and loaded during test. Thermographic images of any connections that fail the test must be submitted with a description of the failure including the probable cause of the failure. A thermographic test shall be performed, but not limited to, the following areas.
1) Service entrance conductors and feeders rated for 100A or more.
e. Inspect cable connectors to verify they are correctly installed.
f. Verify all cables are identified and arranged according to the drawings and specifications.
g. Verify that all cable jackets and insulation are in good condition and did not sustain damage during installation.

2. Electrical Inspection and Testing

a. For feeder current-carrying phase conductors and neutrals: test the insulation resistance with respect to ground for one minute. Cables rated for 300 volts shall be tested with 500 volts DC and cables rated for 600 volts shall be tested with 1000 volts DC. All insulation resistance data gathered shall comply with manufacturer's documentation; if documentation does not exist, comply with the values found in Table 100.1 in the ANSI/NETA ATS-2009.

D. Remove and replace malfunctioning units and retest as specified above.

E. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

END OF SECTION 26 05 19

SECTION 260526 – GROUNDING AND BONDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Field quality-control test reports.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V (or Aluminum where indicated on plans) unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Bonding Cable: stranded conductor sized per NEC 250 requirements.
4. Bonding Conductor: stranded conductor sized per NEC 250 requirements.
5. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; sized per NEC 250 requirements.

C. Grounding Bus: Rectangular bars of annealed copper, 1/4 by 2 inches (6 by 50 mm) in cross section, unless otherwise indicated; with insulators and stand-off brackets.

2.2 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 10 AWG and smaller, and stranded conductors for No. 8 AWG and larger, unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 3/0 AWG minimum. Bury at least 24 inches (600 mm) below grade.

C. Grounding Bus: Install in electrical and telecommunication equipment rooms, in rooms housing service equipment, and elsewhere as indicated. Install bus on insulated spacers 1 inch (25 mm), minimum, with stand-off bracket from wall 6 inches (150 mm) above finished floor, unless otherwise indicated.

D. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors.
3. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits. The raceway shall not be relied on for ground continuity.

B. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide a No. 3/0 AWG minimum insulated grounding conductor (Telecommunications Bonding Backbone, TBB) in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location. Refer to Telecommunications Room Grounding Detail on plans for further requirements.

1. MDF/Headend Room and IDF Rooms: Terminate Telecommunications Bonding Backbone on a grounding bus (Telecommunications Grounding Busbar, TGB). Refer to Telecommunications Room Grounding Detail on plans for requirements.
2. Cabinets, Racks, and Ladder Tray: Extend minimum #10 grounding conductor from equipment to TGB.
3. All telecommunication grounding shall be performed in compliance with TIA/EIA 607 Standard – Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.

3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
3. Provide exothermic-welded connection to building structural steel.
4. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

C. Grounding Bushings and Jumpers: Boxes provided with concentric, eccentric or over-sized knockouts shall be provided with bonding bushings and jumpers lugged to box.

D. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter and Backflow Preventer Piping: Use braided-type bonding jumpers to electrically bypass water meters and backflow preventers where located inside the building. Connect to pipe with a bolted connector.

E. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

B. Testing Technician

1. The testing technicians shall be trained in all the methods of correctly and safely conducting the required test. The technician shall have regular experience conducting the required tests and they must have the knowledge to determine the serviceability of a specific piece of equipment.

C. Physical Inspection and Testing

1. Inspect grounding system to verify that it complies with the requirements in the drawings and specifications, as well as, NFPA 70 *National Electric Code Article 250*.
2. Inspect the physical and mechanical condition and verify that it complies with manufacturer’s standards. All portions of the grounding system shall be free of corrosion.
3. Confirm bolted electrical connections are provided with high impedance using one of the following means:

a. Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar connections. Any similar resistance values that deviate more than 50 percent should be investigated.

b. Inspect the bolted connection and verify that it is at the manufacturer's rated torque using a calibrated torque wrench.

4. Verify that adequate anchorage is in place for the grounding system.

D. Electrical Inspection and Testing

1. Conduct tests for fall of potential as defined by ANSI/IEEE 81 on the grounding system.
2. Determine the resistance to ground throughout grounding system including equipment frames, systems neutral, and equipment grounding bars. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform ground resistance in all of, but not limited to, the areas listed below:

a. Main electrical distribution ground bar: 15 ohms
b. Main telecommunications ground bar: 15 ohms
c. Secondary telecommunications ground bars: 15 ohms
d. Lightning protection path to ground: 5 ohms.

E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

1. Retest required to show compliance with above value.

F. Remove and replace malfunctioning units and retest as specified above.

G. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

END OF SECTION 26 05 26

SECTION 260529 – HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.4 SUBMITTALS

A. Product Data: For anchors, supports, and slotted channel/strut systems.

1.5 QUALITY ASSURANCE

A. Comply with NFPA 70.

1.6 COORDINATION

A. Refer to structural drawing for detail on hanging equipment/conduit from pre-cast planks.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07.

PART 2 - PRODUCTS

2.1 COATINGS

A. Coating: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors shall be hot-dip galvanized.

2.2 MANUFACTURED SUPPORTING DEVICES

A. Raceway Supports: Clevis hangers, riser clamps, two-hole conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps as described in NECA 1 and NECA 101.

B. Fasteners: Types, materials, and construction features as follows:

1. Expansion Anchors: Carbon steel wedge or sleeve type for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
2. Powder-Driven Threaded Studs: Heat-treated steel for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
3. Toggle Bolts: All steel springhead type.
4. Hanger Rods: Threaded steel.

C. Conduit Sealing Bushings: Factory-fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit, or tubing passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.

D. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers. Construct body of malleable-iron casting with hot-dip galvanized finish.

E. U-Channel Systems: Comply with MFMA-4, factory-fabricated components for field assembly; 16-gage steel channels, with 9/16-inch-diameter holes, at a minimum of 8 inches on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacture.

2.3 FABRICATED SUPPORTING DEVICES

A. General: Shop- or field-fabricated supports or manufactured supports assembled from U-channel components.

B. Steel Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.

B. Coordinate with the building structural system and with other electrical installation.

C. Raceway Supports: Comply with the NEC and the following requirements:

1. Conform to manufacturer's recommendations for selection and installation of supports.
2. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 lbs,

provide additional strength until there is a minimum of 200 lbs safety allowance in the strength of each support.

3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
4. Support parallel runs of horizontal raceways together on trapeze-type hangers.
5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4-inch-diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing. Spring steel fasteners are not permitted for use where exposed.
6. Support raceways installed on interior of exterior building walls a minimum of ¼ inch from wall surface using "clamp-back" struts.
7. Space supports for raceways in accordance with Table I of this section. Space supports for raceway types not covered by the above in accordance with NEC.
8. Support exposed and concealed raceway within 1 foot of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or threadless box connectors.
9. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals. Spring steel fasteners are not permitted for use in vertical runs. Support individual vertical runs using two-hole straps. Support parallel runs of vertical raceway together on channel using bolted clamps.
10. On walls and vertical surface, hangers shall not be used below 8' AFF. One-hole or 2-hole straps shall be used to prevent snag hazards created by the exposed fasteners on hangers. Clamp back straps may be used in this application also.

D. Miscellaneous Supports: Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.

E. In open overhead spaces, cast boxes threaded to raceways need not be supported separately except where used for fixture support; support sheet metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 24 inches from the box.

F. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panelboards, transformers, boxes, disconnect switches, and control components in accordance with the following:

1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.
2. Holes cut to depth of more than 1-1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete shall not cut the main reinforcing bars. Fill holes that are not used.
3. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration- and shock- resistant fasteners for attachments to concrete slabs.

3.2 TABLE I: SPACING FOR RACEWAY SUPPORTS

HORIZONTAL RUNS

Raceway Size (Inches)	No. of Conductors in Run	Location	RMC & IMC (1)	EMT (1)	OFR (1)
3/4	1 or 2	Flat ceiling or wall.	5	5	5
3/4	1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction.	7	7	5
3/4	3 or more	Any location.	7	7	...
3/4-1	3 or more	Any location.			
1 & larger	1 or 2	Flat ceiling or wall.	6	6	...
1 & larger	1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction.	10	10	5
1 & larger	3 or more	Any location.	10	10	...
Any	....	Concealed.	10	10	...

VERTICAL RUNS

Raceway Size (Inches)	No. of Conductors in Run	Location	RMC & IMC (1,2)	EMT (1)	OFR (1)
3/4	....	Exposed.	7	7	...
1,1-1/4	....	Exposed.	8	8	...
1-1/2 and larger	....	Exposed.	10	10	...
Up to 2	....	Shaftway.	14	10	...
2-1/2	....	Shaftway.	16	10	...
3 & larger	....	Shaftway.	20	10	...
Any	....	Concealed.	10	10	5

NOTES:

(1) Support spacing listed in feet. Maximum spacing of supports 10 feet.
(2) Maximum spacings for IMC above apply to straight runs only. Otherwise the maximums for EMT apply.

Abbreviations: EMT - Electrical metallic tubing.
IMC - Intermediate metallic conduit.
RMC - Rigid metallic conduit.
OFR- Optic Fiber Raceway

END OF SECTION 26 05 29

SECTION 260533 – RACEWAY AND BOXES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes interior and exterior raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. FMC: Flexible metal conduit.

C. IMC: Intermediate metal conduit.

D. LFMC: Liquidtight flexible metal conduit.

E. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

A. Product Data: For raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Allied Tube & Conduit; a Tyco International Ltd. Co.
   2. O-Z Gedney; a unit of General Signal.
   3. Wheatland Tube Company.

B. Rigid Steel Conduit: ANSI C80.1.

C. IMC: ANSI C80.6.

D. EMT: ANSI C80.3.

E. LFMC: Flexible steel conduit with PVC jacket.

F. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
   1. Fittings for EMT: Plated-steel hexagonal compression type. Cast, pot metal, set-screw, or crimp type fittings are not acceptable.
      a. Couplings shall be "concrete tight" where concealed in masonry.
      b. Box connectors shall be insulated throat type.

G. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

H. Refer to section 3.1, B for raceway color requirements. Provide colored raceway as indicated.

2.2 NONMETALLIC CONDUIT AND TUBING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. AFC Cable Systems, Inc.
   2. Arnco Corporation.
   3. Lamson & Sessions; Carlon Electrical Products.
   4. Thomas & Betts Corporation.

B. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

C. LFNC: UL 1660.

D. Fittings for RNC: NEMA TC 3; match to conduit or tubing type and material.

E. Fittings for LFNC: UL 514B.

2.3 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Arnco Corporation.
   2. Endot Industries Inc.
   3. Lamson & Sessions; Carlon Electrical Products.

B. Description: Comply with UL 2024; flexible type, approved for plenum installation

2.4 METAL WIREWAYS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Cooper B-Line, Inc.
   2. Hoffman.
   3. Square D; Schneider Electric.
   4. Austin Electrical Enclosures

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers:
1. Indoors (dry location): NEMA 1, Hinged type.
2. Exterior & wet/damp locations: NEMA 3R, gasketed type.

E. Finish: Manufacturer's standard enamel finish.

2.5 BOXES, ENCLOSURES, AND CABINETS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
2. EGS/Appleton Electric.
3. Hoffman.
4. RACO; a Hubbell Company.
5. Thomas & Betts Corporation.

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

D. Metal Floor Boxes: Cast or sheet metal, fully adjustable, rectangular. See details on plans.
1. All floor boxes shall meet UL scrub water exclusion requirements.

E. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

F. Cabinets:
1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

2.6 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Fiberglass Reinforced Concrete Handholes: Constructed of polymer concrete and reinforced by heavy-weave fiberglass. Composite material shall be rated for no less than 8,000 lbs. Over a 10”x10” area and tested to temperatures of -50°F. Compressive strength should be no less than 11,000 psi. Covers shall have a minimum coefficient of friction of .5 and have a design load of minimum 15,000 lbs per 10”x10” area. Unit, when buried, shall be designed to support AASHTO H10 loading.

B. Cover Legend: "ELECTRIC" or “COMMUNICATIONS” accordingly.

PART 3 - EXECUTION

3.1 RACEWAY AND BOX APPLICATIONS

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
1. Exposed Conduit: Rigid steel conduit.

2. Concealed Conduit, Aboveground: Rigid steel conduit.
3. Underground Conduit & Duct:
   a. Service Entrance: RNC, Type EPC-40-PVC, direct buried.
   b. Feeders: RNC, Type EPC-40-PVC, direct buried.
   c. Branch Circuit: RNC, Type EPC-40-PVC, direct buried.
   d. Telecommunications: RNC, Type EPC-40-PVC, direct buried.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.

B. Indoors: Apply raceway products as specified below, unless otherwise indicated:
1. Exposed Conduit, Not Subject to Physical Damage: EMT.
2. Exposed Conduit, Subject to Physical Damage: Rigid steel conduit.
   a. Exposed conduit routed vertically and horizontally below 8’ above finished floor in mechanical, electrical, and telecom rooms is considered subject to physical damage.
   b. Exposed conduit routed vertically up through floor slabs shall be considered subject to physical damage until it reaches 8’ above finished floor or enters a box, cabinet, or enclosure.
   c. Exposed conduit routed down vertically from above 8’ which enters boxes, cabinets, or enclosures mounted 48” to top above finished floor or higher is not considered exposed and subject to physical damage and EMT may be used.
3. Conduit Concealed in Ceilings and Interior Walls and Partitions: EMT.
4. Conduit Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
5. Conduit in Damp or Wet Locations: Rigid steel conduit.
6. Raceway Color Coding: Apply color coding to concealed raceway in all spaces and exposed in non-finished areas only.
   a. Fire Alarm Raceway: EMT raceway containing fire alarm wiring shall have a factory applied red color finish.
   b. HVAC Controls Raceway: EMT raceway containing HVAC controls wiring shall have a factory applied blue finish.
   c. Emergency Feeder/Branch Circuit Raceway: EMT raceway containing emergency wiring shall have a factory applied orange finish.
   d. Stand-by Feeder/Branch Circuit Raceway: EMT raceway containing stand-by wiring shall have a factory applied green finish.
   e. Rigid steel conduit used for the above systems shall be field painted to match corresponding EMT Finish.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.
8. Boxes exposed in finished spaces: Boxes shall have solid sides, without pre-punched knockouts.

C. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.

3.2 INSTALLATION

A. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions.

B. Minimum Raceway Size:
1. Interior: 3/4-inch trade size.
2. Exterior, below grade: 1-inch trade size.

C. Conceal conduit and EMT, unless otherwise indicated, within finished walls, ceilings, and floors.

D. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

E. Install raceways level and square and at proper elevations. Provide adequate headroom.

F. Boxes Above Lay-in Ceilings or Access Doors: Install boxes no further than 36” above accessible ceiling/access door.

G. Complete raceway installation before starting conductor installation.

H. Support raceways as specified in Division 26 Section "Hangers and Supports."

I. Use temporary closures to prevent foreign matter from entering raceways.

J. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portion of bends is not visible above the finished slab.

K. Make bends and offsets so ID is not reduced. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated.

L. Use raceway fittings compatible with raceways and suitable for use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings, unless otherwise indicated.

M. Run concealed raceways, with a minimum of bends, in the shortest practical distance considering the type of building construction and obstructions, unless otherwise indicated.

N. Raceways Embedded in Slabs: Raceway shall not be installed embedded within floor and roof slabs, except where connecting to floor boxes. Install in middle third of slab thickness where practical, and leave at least 1-inch (25-mm) concrete cover.
   1. All raceway embedded in slabs shall be rigid galvanized steel conduit.
   2. Raceway shall extend a maximum of 24” from floor box before offsetting beneath slab. Raceway shall extend 12” from penetration of floor slab before transitioning back to electrical metallic tubing.
   3. Space raceways laterally to prevent voids in concrete.
   4. Run conduit parallel to or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
   5. Roofing slab: Raceway shall not be embedded horizontally in roofing slabs.

O. Raceways Installed in Load Bearing Masonry: Raceways installed in load bearing masonry shall be either rigid galvanized steel conduit or coated EMT specifically rated and listed for installation in concrete.

P. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members, and follow the surface contours as much as practical.
   1. Run parallel or banked raceways together, on common supports where practical.
   2. Make bends in parallel or banked runs from same centerline to make bends parallel. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.

Q. Join raceways with fittings designed and approved for the purpose and make joints tight.
   1. Make raceway terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
   2. Use insulating bushings to protect conductors.

R. Terminations: Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against the box. Where terminations are not secure with 1 locknut, use 2 locknuts: 1 inside and 1 outside the box.
   1. Where concentric, eccentric, or over-sized knock outs are encountered, a grounding-type insulated bushing shall be provided.

S. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align raceways so the coupling is square to the box and tighten the chase nipple so no threads are exposed.

T. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of the pull wire.

U. Telecommunications Stub-ups & Sleeves: Provide plastic bushings on all conduit stub-ups and sleeves.

V. Telecommunications Raceways, 4-Inch Trade Size (DN53) and Smaller: In addition to the above requirements, install raceways in maximum lengths of 150 feet (45 m) and with a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes sized per BICSI's Telecommunications Distribution Methods Manual where necessary to comply with these requirements. All bends shall be sweeping long radius manufactured elbows.
   1. Type LB and similar condulet fittings are not permitted for use with any telecommunications raceways.
   2. Flexible metal conduit (FMC) is not permitted for use as a telecommunications raceway.

W. Install raceway sealing fittings according to manufacturer's written instructions. Locate fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
   1. Where conduits pass from warm to cold locations, such as the boundaries of refrigerated spaces.
   2. Where otherwise required by NFPA 70.

X. Stub-up Connections: Where underground raceways are required to turn up into equipment, cabinets, etc., the elbow and stub-up shall be rigid steel. Install with an adjustable top or coupling threaded inside for plugs set flush with the finished floor. Extend to equipment with rigid steel conduit; FMC may be used 6 inches above the floor. Install screwdriver-operated, threaded flush plugs flush with floor for future equipment connections.

Y. Flexible Connections: Use maximum of 6 feet (1830 mm) of flexible conduit for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquidtight flexible conduit in wet or damp locations. Install separate ground conductor across flexible connections.

Z. Set floor boxes level and adjust to finished floor surface.

AA. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:
   1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.
   2. Install backfill as specified in Division 31 Section "Earth Moving."

3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
4. Install manufactured rigid steel conduit elbows for stub-ups at equipment and at building entrances through the floor.
   a. Couple steel conduits to ducts with adapters designed for this purpose.
   b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
5. Depth: Comply with NEC Article 300 for conduit installation depth requirements.
6. Warning Tape: Provide underground-line warning tape specified in Division 26 Section "Electrical Identification." Install 6 to 8” below finished grade.

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.

D. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.6 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

3.7 PAINTING

A. Where conduits are installed exposed in finished spaces, contractor shall paint to match adjacent finishes. Where adjacent finishes are not painted (e.g. natural, faux, patterns, etc.), contractor shall get approval on paint selection from the design team prior to painting.

END OF SECTION 26 05 33

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SECTION 260536 – CABLE TRAYS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes cable trays and accessories.

1.3 SUBMITTALS

A. Product Data: Include data indicating dimensions and finishes for each type of cable tray indicated.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain cable tray components through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

D. Comply with NEMA VE 1 – Metal Cable Tray Systems.

E. Comply with NEMA VE 2 – Cable Tray Installation Guidelines.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store indoors to prevent water or other foreign materials from staining or adhering to cable tray. Unpack and dry wet materials before storage.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Cablofil.
2. Cooper B-Line, Inc.
3. Cope, T. J., Inc.; a subsidiary of Allied Tube & Conduit.
4. MPHusky.
5. MonoSystems, Inc.

2.2 CABLE TRAY TYPES

A. Cable Tray Type:

1. MDF & IDF Room Ladder Rack: Telco Style Tubular Runway; configuration and widths as indicated on plans. Finish: Black. Basis of Design: Ortronics TRT10 Series.

B. Provide straight tray sections in standard foot lengths, except where shorter lengths are permitted to facilitate tray assembly lengths as shown on drawings

C. Fabricate cable tray products with rounded edges and smooth surfaces.

D. Sizes and Configurations: Refer to floor plans for cable tray widths.

E. Cable Trays shall meet NEMA 12C class designation.

2.3 WIRE MESH TRAY

A. General: Provide wire mesh tray of types and sizes indicated; with connector assemblies, clamp assemblies, connector plates, splice plates and splice bars. Construct units with rounded edges and smooth surfaces; in compliance with applicable standards; and with the following additional construction features.

B. Materials and Finishes: Material and finish specifications for carbon steel wire are as follows:
1. Electro-Plated Zinc Galvanizing: Straight sections shall be made from steel meeting the minimum mechanical properties of ASTM A 510, Grade 1008 and shall be electro-plated zinc in accordance with ASTM B633, Type III, SC-1.

C. Construction and Assembly:
1. Wire mesh shall be made of high strength 0.196” minimum diameter steel wires and formed into a standard 2 inch by 4 inch wire mesh pattern with intersecting wires welded together. All mesh sections must have at least one bottom longitudinal wire along entire length of straight section.
2. All straight section longitudinal wires shall be constructed with a continuous top wire safety edge. Safety edge must be kinked and T-welded on all tray sizes.
3. All fittings shall be field formed, from straight sections, in accordance with manufacturer’s instructions.
4. All splicing assemblies shall be UL/CSA approved as an Equipment Ground Conductor (EGC).
5. Wire basket supports shall be standard trapeze hangers or wall brackets as manufactured by cable tray manufacturer. Center support hangers are not acceptable.
6. Trapeze hangers shall be supported by 1/4 inch or 3/8 inch diameter rods.
7. Special accessories shall be furnished as required to protect, support and install a wire basket support system.

2.4 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.5 SOURCE QUALITY CONTROL

A. Perform design and production tests according to NEMA VE 1.

PART 3 - EXECUTION

3.1 GENERAL CABLE TRAY INSTALLATION

A. Coordinate tray installation with other electrical work as necessary to properly interface installation of wire basket runway with other work.

B. Comply with recommendations in NEMA VE 2. Install as a complete system, including all necessary fasteners, hold-down clips, splice-plate support systems, barrier strips, hinged horizontal and vertical splice plates, elbows, reducers, tees, and crosses.

C. Remove burrs and sharp edges from cable trays.

D. Fasten cable tray supports to building structure.
1. Place supports so that spans do not exceed maximum spans on schedules.
2. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
3. Design supports, including fastenings to the structure, to carry the greater of the calculated load multiplied by a safety factor of 4 or the calculated load plus 200 lb (90 kg).
4. Locate and install supports according to NEMA VE 1.

E. Make connections to equipment with flanged fittings fastened to cable tray and to equipment. Support cable tray independent of fittings. Do not carry weight of cable tray on equipment enclosure.

F. Install expansion connectors where cable tray crosses building expansion joint and in cable tray runs that exceed dimensions recommended in NEMA VE 1. Space connectors and set gaps according to applicable standard.

G. Make changes in direction and elevation using standard fittings.

H. Make cable tray connections using standard fittings.

I. Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Firestopping."

J. Grounding: Provide insulated ground conductor from tray to grounding busbar in telecom rooms. Provide insulated ground conductor from tray to building steel for tray installed in corridors. Provide bonding jumper between individual sections of tray.

K. Workspace: Install cable trays with enough space to permit access for installing cables. Install a minimum of 4” above grid ceiling system and provide a minimum of 6” clearance above tray for installation of cables.

3.2 INSTALLATION OF WIRE MESH TRAY

A. All fittings shall be field formed, from straight sections, in accordance with manufacturer’s instructions.
1. Bends/Turns: All changes in horizontal direction shall performed using sweeping bends with minimum internal radius equal to tray width created from a single section. 90° corners are not acceptable. Creating bend/turn from two sections of tray is not acceptable.
2. T-Fittings: Use 45° angle chamfer on intersection corners. Chamfer length shall be minimum half width of intersecting tray. 90° corners are not acceptable.
3. Reductions: Reductions shall be limited to left or right side with the other side remaining straight. Use maximum 30° transition angle between sections of different widths.

4. Elevation Changes: Use maximum 30° transition angle between elevations. Multiple sections shall not joined at elevation changes.

3.3 GROUNDING

A. Ground cable trays according to manufacturer's written instructions.

3.4 FIELD QUALITY CONTROL

A. After installing cable trays survey for compliance with requirements. Perform the following field quality-control survey:
1. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable tray, vibration, and thermal expansion and contraction conditions, which may cause or have caused damage.
2. Verify that there is no intrusion of such items as pipe, hangers, or other equipment that could damage cables.
3. Remove deposits of dust, construction materials, and trash of any description.
4. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
5. Check for missing or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
6. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable tray.

B. Testing: Test wire basket support systems to ensure electrical continuity of bonding and grounding connections, and to demonstrate compliance with specified maximum grounding resistance. See NFPA 70B, Chapter 18, for testing and test methods.

3.5 PROTECTION

A. Protect installed cable trays.
1. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.

END OF SECTION 26 05 36

SECTION 260553 – IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes electrical identification materials and devices required to comply with ANSI C2, NFPA 70, OSHA standards, and authorities having jurisdiction.

1.3 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Identification Schedule: An index of nomenclature of all electrical equipment and system components used in identification signs and labels. Schedule shall depict preliminary printouts of proposed equipment labels for review prior to order.

1.4 QUALITY ASSURANCE

A. Comply with ANSI C2.

B. Comply with NFPA 70.

C. Comply with ANSI A13.1 and NFPA 70 for color-coding.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

PART 2 - PRODUCTS

2.1 RACEWAY AND CABLE LABELS

A. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide (0.08 mm thick by 25 to 51 mm wide).

B. Underground-Line Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape.
1. Not less than 6 inches wide by 4 mils thick (152 mm wide by 0.102 mm thick).
2. Compounded for permanent direct-burial service.
3. Embedded continuous metallic strip or core.
4. Printed legend indicating type of underground line.

C. Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.

D. Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, unless otherwise indicated, with eyelet for fastener.

2.2 NAMEPLATES AND SIGNS

A. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.

B. Engraved Plastic Nameplates and Signs: Engraving stock, melamine plastic laminate, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. in. (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.
   1. Punched or drilled for mechanical fasteners.

C. Baked-Enamel Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for the application. 1/4-inch (6.4-mm) grommets in corners for mounting.

D. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for the application. 1/4-inch (6.4-mm) grommets in corners for mounting.

E. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32, stainless-steel machine screws with nuts and flat and lock washers.

2.3 CEILING TAGS

A. Ceiling Tags: 0.030-inch thick and 3/4 to 7/8-inch diameter rigid vinyl, self-adhesive, white or clear plastic tags with pre-printed, minimum 1/8-inch tall block-letter black text indicating the equipment, valve or accessory tag and number designations.

B. Ceiling grid markers shall be the color as indicated. Beside all colored grid markers, a printed label shall be used to specify what the color marker is locating. Labels shall be no more than 1-inch in height. Lettering shall be minimum 18-point font. Lettering shall be black on white tape.
   1. Neon Red Sticker: Electrical – Pull Box/Future/Disconnects, etc.
   2. Neon Green: CCTV Camera Drops
   3. Neon Orange: Wireless Access Points
   4. Red Sticker: Fire Alarm/Sprinklers/Life Safety

2.4 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
   1. Minimum Width: 3/16 inch (5 mm).
   2. Tensile Strength: 50 lb (22.3 kg) minimum.
   3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
   4. Color: According to color-coding.

B. Paint: Formulated for the type of surface and intended use.
   1. Primer for Galvanized Metal: Single-component acrylic vehicle formulated for galvanized surfaces.
   2. Primer for Concrete Masonry Units: Heavy-duty-resin block filler.
   3. Primer for Concrete: Clear, alkali-resistant, binder-type sealer.
   4. Enamel: Silicone-alkyd or alkyd urethane as recommended by primer manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Identification Materials and Devices: Install at locations for most convenient viewing without interference with operation and maintenance of equipment.

B. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations with corresponding designations in the Contract Documents or with those required by codes and standards. Use consistent designations throughout Project.
1. General 277/480V and 120/208V Equipment: Black label with white core.
2. Emergency Generation & Distribution Equipment: Orange label with white core.
3. Stand-by Distribution Equipment: Green label with white core.
4. Fire Alarm Equipment: Red label with white core.
5. Voice, Data & Video Systems: Blue label with white core.
6. Security Systems: Burgundy label with white core.

C. Ceiling Tag Installation
1. Install ceiling tags on lay-in grid and access doors below equipment, boxes, camera drops, Wireless Access Points (WAPs), and Fire Alarm devices above finished ceilings. Center tags on grid members and doors.

D. Sequence of Work: If identification is applied to surfaces that require finish, install identification after completing finish work.

E. Self-Adhesive Identification Products: Clean surfaces before applying.

F. Install painted identification according to manufacturer's written instructions and as follows:
1. Clean surfaces of dust, loose material, and oily films before painting.
2. Prime surfaces using type of primer specified for surface.
3. Apply one intermediate and one finish coat of enamel.

G. Color Banding Raceways and Exposed Cables: Band exposed and accessible raceways of the systems listed below. Banding of colored conduit is not required.
1. Bands: Pre-tensioned, wraparound plastic sleeves; colored adhesive tape; or a combination of both. Make each color band 2 inches (51 mm) wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side.
2. Band Locations: At changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas. Also provide color banding at outlet box stub-ups.
3. Apply the following colors to the systems listed below:
   a. Fire Alarm System: Red.
   b. HVAC Controls Raceway: Blue.
   c. Emergency Systems: Orange.
   d. Stand-by Systems: Green.
   e. Telecom/LV Systems: Yellow
4. Color code cover of raceway junction boxes following the colors listed above.
5. Spare raceway for future use shall be identified as such and shall indicate where raceway originates and terminates on each end.

H. Caution Labels for Indoor Boxes and Enclosures for Power and Lighting: Install pressure-sensitive, self-adhesive labels identifying system voltage with black letters on orange background. Install on exterior of door or cover.

I. Circuit Identification Labels on Outlet Boxes, Junction Boxes and Pull Boxes: Install labels externally.
   1. Outlet boxes (receptacles and switches) and exposed junction boxes: Pressure-sensitive, self-adhesive plastic label on faceplate. Use clear label with black letters.
      a. Floor boxes and Weatherproof In-use covers: Labels shall be inside the box/cover in an easily readable location when the cover is open. In-use covers: labels shall be on the side of the box interior.
   2. Concealed junction and pull boxes: Neat handwritten label using permanent black marker.
   3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.
   4. Future Use Circuits: Circuits for future use shall be identified as such and list panel and circuit number of source.

J. Secondary Service, Feeder, and Branch-Circuit Conductors: Color-code throughout the secondary electrical system.
   1. Color-code 208/120-V system as follows:
      a. Phase A: Black.
      b. Phase B: Red.
      c. Phase C: Blue.
      d. Neutral: White.
      e. Ground: Green.
   2. Color-code 480/277-V system as follows:
      a. Phase A: Brown.
      b. Phase B: Orange.
      c. Phase C: Yellow.
      d. Neutral: Gray.
      e. Ground: Green.
   3. Factory apply color the entire length of all conductors, except the following field-applied, color-coding methods may be used instead for service conductors:
      a. Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Use 1-inch- (25-mm-) wide tape in colors specified. Adjust tape bands to avoid obscuring cable identification markings.
      b. Colored cable ties applied in groups of three ties of specified color to each wire at each terminal or splice point starting 3 inches (76 mm) from the terminal and spaced 3 inches (76 mm) apart. Apply with a special tool or pliers, tighten to a snug fit, and cut off excess length.

K. Apply identification to conductors as follows:
   1. Conductors to Be Extended in the Future: Indicate source and circuit numbers.
   2. Multiple Power or Lighting Circuits in the Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color-coding to identify circuits' voltage and phase.
   3. Multiple Control and Communication Circuits in the Same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color-coding, or cable marking tape.

L. Apply warning, caution, and instruction signs as follows:
   1. Warnings, Cautions, and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
   2. Emergency Operation: Install engraved laminated signs with white legend on red background with minimum 3/8-inch- (9-mm-) high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.

M. Equipment Identification Labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. Locate label on exterior of any enclosure. This includes power, lighting, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise indicated, provide three lines of text with 1/4-inch high lettering on 1-1/2-inch high label; where four lines of text are required, use labels 2 inches high. Use surface and core colors as listed in Part 2 above. Provide labels for all electrical equipment listed below. In general, all labels shall include riser diagram ID, amperage, voltage, number of phases/poles, and equipment served from (source). Provide additional information as listed below:
   1. Switchboard: include bus amperage and mimic bus.
   2. Panelboards: MCB/MLO.
   3. Disconnect switches: equipment served by.
      a. Provide label for all disconnects provide by Division 23, 24 or 26.
   4. Enclosed circuit breakers: equipment served by.
      a. Provide label for all disconnects provide by Division 23, 24 or 26.
   5. Contactors & Relay Panels.
   6. Transformers: equipment served by.
   7. Generator Systems
   8. Transfer Switches: normal power source, emergency power source, and panelboard served by.
   9. Fire Alarm Control Panel and auxiliary power supplies and enclosures.

END OF SECTION 26 05 53

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SECTION 26 05 71 - POWER SYSTEM STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes a computer-based power system one-line model, fault current analysis, overrcurrent setting/trip coordination, and arc flash study including gathering power system field data and submitting study reports to determine:

1. Minimum interrupting capacity of circuit protective devices.
2. Overcurrent protective devices and to determine overcurrent protective device settings for selective coordination tripping.
3. Arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

B. The Contractor shall be responsible to fully coordinate all overcurrent protective devices within the scope of work, unless indicated otherwise.

C. The extent of the electrical power system to be studied is indicated on Drawings; unless otherwise noted, scope shall include all new protective devices and equipment, and in renovations and additions their next higher and lower existing devices and equipment.

1.3 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Pre-Installation Submittal: Included with major distribution equipment submittal, shall be a preliminary study report prepared using actual submitted equipment and overcurrent protective devices.

1. Refer to “Report Content” articles below for submittal requirements.
2. Feeder lengths shall be based on actual Contractor take-offs, using typical minimum lengths is not acceptable.

3. Preliminary submittal shall include copy of proposed flash warning labels.

B. Post-Installation Submittal: Up to 30 days prior to Substantial Completion, Contractor shall submit an updated report.

1. Updated report shall include actual equipment installed and measured feeder lengths.
2. Copy of updated proposed flash warning labels shall also be included.
3. After Engineer approval of post-installation report Contractor shall generate and install adhesive flash warning labels.
4. All study and equipment evaluation reports; signed, dated, and sealed by a qualified professional engineer study specialist.

1.5 CLOSEOUT SUBMITTALS

A. A copy of the final corrected Study shall be included with the Owner's Operations & Maintenance Manuals.

1.6 QUALITY ASSURANCE

A. Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

B. Computer Software:

1. SKM Power Tools
2. ESA Easy Power

C. Comply with IEEE 242, 399, 551, 1584, and NFPA 70E.

PART 2 - POWER SYSTEM STUDY PROCEDURES

2.1 EXAMINATION

A. This article lists data needed to conduct the study. Contractor is responsible for gathering all data not included in the one-line drawings that are part of the Contract Documents.

B. Obtain all data necessary for the conduct of the study.

1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Architect and Engineer.
2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.
4. For relocated equipment and that which is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

2.2 INPUT DATA

A. Gather and tabulate the following input data to support the power system study. Comply with recommendations in IEEE 551, IEEE 1584, and NFPA 70E as to the amount of detail that is required to be

acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Electrical power utility impedance at the service.
3. Power sources and ties.
4. Voltage level at each bus.
5. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
9. Motor horsepower and NEMA MG 1 code letter designation.
10. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
11. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:

a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    a. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
    b. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    c. Generator thermal-damage curve.
    d. Ratings, types, and settings of utility company's overcurrent protective devices.
    e. Special overcurrent protective device settings or types stipulated by utility company.
    f. Time-current-characteristic curves of devices indicated to be coordinated.
    g. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
    h. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.

2.3 SHORT CIRCUIT STUDY PROCEDURE

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. All equipment depicted on electrical distribution riser diagram, as well as all motors 30 horsepower and larger, shall be included in system model. Fault contribution to system shall be based on available fault current on secondary of service transformer as provided by utility company, or other fault current source(s), whichever is largest.

F. Begin short-circuit current analysis at the service, extending down to all the system overcurrent protective devices.

G. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

H. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators 30 horsepower and larger, and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

I. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:

1. Electric utility's supply termination point.
2. Incoming switchgear.
3. Unit substation primary and secondary terminals.
4. Low-voltage switchgear & switchboards.
5. Motor-control centers.
6. Motor control panels (Elevators, HVAC, etc).
7. Standby generators and automatic transfer switches.
8. Distribution & branch circuit panelboards.
9. Disconnect switches.

2.4 OVERCURRENT PROTECTIVE DEVICE STUDY PROCEDURE

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. The study shall be based on the device characteristics supplied by device manufacturer.

D. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:
   a. Inrush current when first energized.
   b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
   c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

E. Motor Protection:

1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.

F. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection

or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

G. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.

H. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

I. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:

1. Electric utility's supply termination point.
2. Switchgear.
3. Unit substation primary and secondary terminals.
4. Low-voltage switchgear.
5. Motor-control centers.
6. Standby generators and automatic transfer switches.
7. Distribution & branch circuit panelboards.

J. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.

2.5 ARC FLASH STUDY PROCEDURES

A. Comply with IEEE 1584, and NFPA 70E and its Annex D for hazard analysis study.

B. Preparatory Studies:

1. Short-Circuit Study Section 2.3
2. Protective Device Coordination Study Section 2.4

C. Calculate maximum and minimum contributions of fault-current size.

1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.

E. Include medium- and low-voltage equipment locations, except equipment rated 240-V ac or less with an available short-circuit current less than 2 kA as determined by the short-circuit study.

F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.

G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond three to five cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:

1. When the circuit breaker is in a separate enclosure.
2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

PART 3 – POWER SYSTEM STUDY DELIVERABLES

3.1 REPORT CONTENT

A. Executive summary.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings depicted on the electrical distribution riser diagram.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. The overcurrent/ground fault setting coordination shall create a set of time-current curves depicting successive breakers and fuses for each unique distribution system branch. Coordination shall be to 0.06 seconds, unless the AHJ requires 0.01 seconds.

E. Comments and recommendations for system improvements, where study results fail to meet design intent, specified requirements or industry standards.

F. Study Input Data: As described in Section 2.2.

G. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.

2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

H. Short-Circuit Study Output:

1. The fault current analysis portion of the report shall include a print out from the software listing the available three-phase, Line-Line, and Line-Ground fault current at each piece of equipment and highlight exceeded equipment ratings.
2. Low-Voltage Fault Report: Three-phase, Line-Line, and Line-Ground fault calculations, showing the following for each overcurrent device location:
   a. Voltage.
   b. Calculated fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. Equivalent impedance.

I. Protective Device Coordination Study Ouput:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
   a. Circuit Breakers:
      1) Adjustable pickups and time delays (long time, short time, ground).
      2) Adjustable time-current characteristic.
      3) Adjustable instantaneous pickup.
      4) Recommendations on improved trip systems, if applicable.
   b. Fuses: Show current rating, voltage, and class.

J. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:
   a. Power utility's overcurrent protective device.
   b. low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
   c. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
   d. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
   e. Cables and conductors damage curves.
   f. Ground-fault protective devices.
   g. Motor-starting characteristics and motor damage points.
   h. Generator short-circuit decrement curve and generator damage point.

i. The largest feeder circuit breaker in each motor-control center and panelboard.

5. Provide adequate time margins between device characteristics such that selective operation is achieved.
6. Comments and recommendations for system improvements.

K. Arc-Flash Study Output:

1. Incident Energy and Flash Protection Boundary Calculations:
   a. Arcing fault magnitude.
   b. Protective device clearing time.
   c. Duration of arc.
   d. Arc-flash boundary.
   e. Working distance.
   f. Incident energy.
2. Summary narrative of recommendations including overcurrent trip setting adjustments for arc-flash energy reduction to Owner's standard protection ratings.

3.2 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch (76-by-127-mm) self-adhesive equipment label for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis, and comply with NFPA 70E:

1. Location designation.
2. Nominal voltage.
3. Flash protection boundary.
4. Hazard risk category.
5. PPE required.
6. Incident energy.
7. Working distance.
8. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings.

D. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations, or as required by Owner's standard:

1. Motor-control center.
2. Low-voltage switchboard.
3. Switchgear.
4. Control panel.

E. Install the arc-fault warning labels under the direct supervision and control of the Study Specialist.

3.3 FIELD ADJUSTING

A. Make minor modifications to equipment as required to accomplish compliance with short-circuit, protective device coordination, and arc flash studies.

END OF SECTION 26 05 71

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SECTION 260923 – LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following lighting control devices:
   1. Occupancy sensors.
   2. Lighting contactors.
   3. Lighting Relay Devices
   4. Emergency lighting relay devices.
   5. Photocells

B. Related Sections include the following:
   1. Division 26 Section "Wiring Devices" for manual light switches.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. PIR: Passive infrared.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 OCCUPANCY SENSORS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Acuity Brands Lighting, Inc.
2. Cooper Lighting Solutions
3. Hubbell Control Solutions
4. Leviton Manufacturing Co., Inc.
5. Lutron Electronics Co., Inc.
6. Wattstopper (division of Legrand North America, LLC).

B. Wall-box Line Voltage Occupancy Sensor: Wall-box, solid-state units with integral relay(s)
1. Basis of Design: Wattstopper DSW-301 (single relay) or DSW-302 (dual relay).
2. Operation: Unless otherwise indicated, turn lights on when button(s) are pushed and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 5 to 30 minutes. Capable of being set to either automatic on or manual on.
3. Must be capable of controlling lighting and fans for bathroom exhaust.
4. Neutral conductor connection is required.
5. PIR Sensor: Detect occupancy by sensing a combination of heat and movement in area of coverage.
6. Ultrasonic Sensor: Emits inaudible sound patterns at frequencies that are above human sensitivity, that cross the space and return. Motion in the space changes the pattern of the waves, activating the sensor.
7. Detector Sensitivity: Detect occurrences of 6-inch minimum movement of any portion of a human body that presents a target of at least 36 sq. in.
8. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A.
9. Relay Unit: Dry contacts rated for 800 W ballast or tungsten load at 120-V ac and for 1200 W ballast load at 277-V ac, and for 1/6 hp at 120-V ac.
10. Mounting: Suitable for mounting in a standard outlet box.
11. Indicator: LEDs, to show when motion is being detected during testing and normal operation of the sensor. Detection LEDs: Red = PIR, Green = Ultrasonic
12. On/Bypass Switch: Provides manual on function or overrides the automatic on function in case of sensor failure.

C. Ceiling & Wall Mount Low-Voltage Occupancy Sensor: Ceiling or wall mounted 24-volt occupancy sensors with separate relay/power pack.

1. Basis of Design:
   a. Sensor: Wattstopper DT-300 (~1000 sq. ft. coverage).
   b. Power Pack: Wattstopper BZ-200
2. Occupancy Sensors: Sensors shall be dual technology and utilize both infrared and ultrasonic sensing mechanisms.
   a. Electrical: 24 VDC/VAC
   b. Time Delays: 5, 10, 15, 20, or 30 Minutes, Walk-thru/Test Modes
   c. Isolated Relay (for integration with BAS): N/O and N/C outputs; rated for 1 Amp @ 30 VDC/VAC
   d. Built-in Light Level Sensor: 10 to 300 Footcandles
   e. Passive infrared sensor: Fresnel lens provides 360° coverage.
   f. Ultrasonic sensor shall have an operating frequency of 40kHz,
   g. Sensors shall be fully adaptive and adjust their sensitivity and timing to ensure optimal lighting control for any use of the space.
   h. Sensors shall have optional readily accessible, user adjustable controls for time delay and sensitivity that can override any adaptive features.
   i. Indicator: LEDs, to show when motion is being detected during testing and normal operation of the sensor. Detection LEDs: Red = PIR, Green = Ultrasonic.
3. Power Packs: Power pack shall be able to mount in junction box, self-contained unit consisting internally of an isolated load switching control relay and a transformer to provide low-voltage power. Transformer shall provide power to a minimum of three (3) sensors
   a. Power pack shall be plenum rated

D. Control wiring between sensors and control units shall be Class 2, 18-24 AWG, stranded U.L. Classified, PVC insulated or TEFLON jacketed cable in conduit.

2.2 LIGHTING CONTACTORS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Products.
   2. GE Industrial Systems; Total Lighting Control.
   3. Siemens Energy & Automation, Inc.
   4. Square D; Schneider Electric.

B. Description: Electrically operated and electrically held, complying with NEMA ICS 2 and UL 508.
   1. Hand, Auto, OFF, functionality switch for manual overrise control
   2. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
   3. Enclosure: Contactors shall be mounted in NEMA 1 enclosure where located indoors and in NEMA 4 enclosure where located outdoors or in damp or wet locations.
   4. Control Coil Voltage: Match control power source, unless otherwise noted on plans.

2.3 LIGHTING RELAY DEVICES

A. Basis of design:
   1. Wattstopper - ELCU-200
      a. For exposed ceiling locations
   2. Wattstopper - AD-EPC-D-F-ATS
      a. For areas with ACT tile or hard ceilings (i.e. classrooms)

B. Description: Emergency Lighting Transfer Switch converts up to 16A of normal light fixtures to approved emergency lights.
   1. Integral test switch with self-testing option
   2. Compatible with 0-10V dimming controls
   3. Rated for 120-277V
   4. Flush, fixture, plenum, or panel mounting
   5. Utility, emergency, power LEDS

2.4 PHOTOCELLS

A. Available Manufacturers:
   1. INTEMATIC
   2. Or approved equal

B. Description: Fixed mount exterior electronic photocontrols. Non=drift silicon light sensor with IF filter.
   1. ½”-14 NPSM threaded stem fits standard outlet boxes.
   2. A minimum of 9” #18 wire leads.
   3. Integral surge protection element
   4. Control capabilities for LED fixtures for a minimum of 1600 watts
   5. A minimum of 15 year design lift.

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

B. Where options specified are not enabled by default and require adjustment of dip switch settings, the contractor is responsible for making these adjustments (e.g. audible and visual warnings on digital timer switches).

3.2 CONTACTOR INSTALLATION

A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

A. Wiring Method: Comply with Division 26 Section "Conductors and Cables."

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."
   1. Identify controlled circuits in lighting contactors and branch circuit emergency lighting transfer devices.

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
   2. Operational Test: Verify operation of each lighting control device, and adjust time delays.

B. Lighting control devices that fail tests and inspections are defective work. Repair, or replace, and retest.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

SECTION 262200 - DRY-TYPE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes power distribution control dry-type transformers rated 600 V and less.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.4 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS (MATERIALS FURNISHED UNDER SEPARATE PACKAGE)

2.1 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

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

3.2 INSTALLATION

A. Comply with safety requirements of IEEE C2.

B. Arrange equipment to provide adequate spacing for access and for circulation of cooling air.

C. Install floor-mounted transformers on concrete base, 4-inch (100-mm) nominal thickness extending 2” beyond enclosure with chamfered edge. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete."

D. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

E. Grounding: Provide single, multi-barrel (conductor) mechanical grounding lug for all grounding and bonding connections in transformer.

3.3 EQUIPMENT TESTING

A. Physical Inspection and Testing

1. Verify equipment rating correspond to drawings and specifications.
2. Inspect the physical and mechanical condition and verify that it complies with manufacturer’s standards.
3. Verify equipment is properly secured and aligned with the required clearances as specified in the drawings and specifications. Assure that the equipment is properly grounded.
4. Verify that all packing materials have been removed and the equipment has been cleaned.
5. Confirm bolted electrical connections are provided with high impedance using one of the following means:

    a. Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar connections. Any similar resistance values that deviate more than 50 percent should be investigated.

    b. Inspect the bolted connection and verify that it is at the manufacturer’s rated torque using a calibrated torque wrench. If manufacturer’s data is not available verify the torque meets the requirements of Table 100.12 in the ANSI/NETA ATS-2009.

B. Electrical Inspection and Testing

1. Measure the secondary voltage from phase to phase and from phase to ground to verify it meets the requirements of the drawings and specifications as well as the equipment rating. Measurements should be taken after the transformer has been energized but prior to transformer loading.

C. Test Reports: Prepare a written report to record the following:

1. Document primary and secondary voltages on transformers. L-L, L-N and L-G all phases.

3.4 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

3.5 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Remove paint splatters and other spots, dirt, and debris. Repair scratches and mars on finish to match original finish. Clean components internally using methods and materials recommended by manufacturer.

END OF SECTION 262200

SECTION 262413 – SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Refer to Section 260571 “Power System Study” for overcurrent protective device coordination and submittal requirements.

1.2 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Disconnecting and overcurrent protective devices.
3. Surge protective device.
4. Instrumentation.
5. Accessory components and features.
6. Identification.
7. Mimic bus.

1.3 SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Refer to Section 260571 for Fault Current Coordination and ARC Flash Report requirements.

C. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards, store indoors, and provide temporary heating according to manufacturer’s written direction to prevent condensation.

C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.5 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations: Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.6 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS (FURNISHED UNDER SEPARATE CONTRACT)

2.1 IDENTIFICATION

A. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on an engraved laminated-plastic nameplate.

B. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.

C. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to switchboards.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Install filler plates in unused spaces of panel-mounted sections.

E. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.

3.3 CONNECTIONS

A. Install equipment grounding connections for switchboards with ground continuity to main electrical ground bus.

B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

3.4 IDENTIFICATION

A. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Physical inspection and Testing

a. Verify equipment rating correspond to drawings and specifications.
b. Inspect the physical and mechanical condition and verify that it complies with manufacturer’s standards.
c. Verify equipment is properly secured and aligned with the required clearances as specified in the drawings and specifications. Assure that the equipment is properly grounded.
d. Verify that all packing materials have been removed and the equipment has been cleaned.
e. Confirm all breaker sizes, quantities, and configurations correspond to the drawings and specifications.
f. Confirm bolted electrical connections are provided with high impedance using one of the following means:
1) Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar

connections. Any similar resistance values that deviate more than 50 percent should be investigated.

2) Inspect the bolted connection and verify that it is at the manufacturer's rated torque using a calibrated torque wrench. If manufacturer's data is not available verify the torque meets the requirements of Table 100.12 in the ANSI/NETA ATS-2009.

g. A thermographic test shall be conducted. Equipment will be open at the time of the scan in order to get an accurate reading from the testing device. All equipment should be energized and loaded during test. Thermographic images of any connections that fail the test must be submitted with a description of the failure including the probable cause of the failure.

h. Inspect any moving electrical components and ensure that proper lubricant is applied to allow for easy operation.

i. Verify insulators have not sustained physical damage or been exposed to contamination.

j. Verify all active components operate correctly.

2. Electrical Inspection and Testing

a. Test ground resistance at the main electrical distribution ground bus.

b. Verify all meters functionality and accuracy after testing and calibrating all inputs.

c. Verify transformers meet all the requirements of the drawings and specifications.

1) Test transformer wiring integrity and proper transformer operation.

2) Verify transformer output voltage is at the specified level.

d. Verify phases are connected to the same bus for switchboards with multiple sources so that loads do not cross phases when sources are transitioned.

3. Test Reports: Prepare a written report to record the following:

a. Test procedures used.

b. Test results that comply with requirements.

c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

3.6 ADJUSTING

A. Set field-adjustable circuit-breaker trip ranges. Unless otherwise noted, trip settings shall mimic trip characteristics for thermal magnetic circuit-breakers of similar trip rating.

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 CLEANING

A. On completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories.

END OF SECTION 26 24 13

SECTION 262416 – PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Refer to Section 260571 “Power System Study” for overcurrent protective device coordination and submittal requirements.

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.

1.3 DEFINITIONS

A. SVR: Suppressed voltage rating.

B. SPD: Surge Protective Device.

1.4 SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Refer to Section 260571 for Fault Current Coordination and ARC Flash Report requirements.

C. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

D. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

E. Panelboard Schedules: For installation in panelboards. Room names and numbers shall match the final signage at the site. Submit final versions prior to installation in panelboard.

F. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Handle and prepare panelboards for installation according to NEMA PB 1.

1.7 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.8 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available 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:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

2.2 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Enclosures: Flush- and surface-mounted cabinets as noted on schedules.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
b. Outdoor Locations: NEMA 250, Type 4.
c. Kitchen Areas: NEMA 250, Type 4X stainless steel.
d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

2. Front Cover: For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.

a. Flush Mounted Panelboards: Standard front cover. Secured to box with concealed trim clamps. Match box dimensions.
b. Surface Mounted Panelboards: Entire front trim hinged to box. Continuous piano hinge. Provide standard door with front trim.

3. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.

4. Finishes:

a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
b. Back Boxes: Galvanized steel.

5. Directory Card: Inside panelboard door, mounted in plastic sleeve.
6. Main Overcurrent Protective Devices: Molded-case circuit breakers.
   a. Center Mounted Main: Branch mounted main breakers are not allowed.
7. Branch Overcurrent Protective Devices: Molded-case circuit breakers.
   a. Center mounted branch devices and sub-feed branch devices are not allowed.

B. Incoming Mains Location: Top and bottom.

C. Phase, Neutral, and Ground Buses: Hard-drawn copper, 98 percent conductivity

1. Neutral Bus: Neutral bus rated 100 percent of phase bus.

2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

D. Main and Neutral Lugs: Mechanical type suitable for use with conductor material.

E. Feed-through Lugs: Not acceptable.

F. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the design drawings. If it is not possible to match "specific breaker placement" during construction, clearly note in submittal documentation for approval.

G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices. Future devices indicated as “SPACE” on drawings.

H. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Series rating of equipment is not acceptable.

2.3 DISTRIBUTION PANELBOARDS

A. Panelboards: NEMA PB 1, power and feeder distribution type.

B. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.

C. Mains: Circuit breaker.

D. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

B. Mains: Circuit breaker, unless otherwise noted on drawings.

C. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

D. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with full interrupting capacity to meet available fault currents.

1. Electronic Trip Circuit Breakers: Electronic trip circuit breakers with RMS sensing; field-replaceable rating plug or field-replicable electronic trip and individually field-adjustable long

time, short time, and instantaneous trip pickup level settings. Trip unit shall also have adjustable long time and short time delay settings. Provide for circuit-breaker frame sizes 250A and larger.

a. Ground Fault Protection: Any 1000A-rated circuit breaker or larger, above 150V L-G, shall have ground fault pickup and time delay settings in addition to overcurrent trip settings indicated above.

2. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Field adjustable instantaneous trip setting for circuit-breaker frame sizes 100 A to 225A.
3. Breakers Serving Elevator Controllers: Field adjustable instantaneous-trip setting for circuit-breaker.
4. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
5. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
6. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
7. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
e. Shunt Trip: Trip coil energized from separate circuit, set to trip at 75 percent of rated voltage. Match coil voltage to control power source.
f. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
g. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
h. Handle Clamp: Loose attachment,for holding circuit-breaker handle in on position.

2.6 SURGE PROTECTIVE DEVICES

A. General: Externally mounted, modular, solid-state, parallel-connected, sine-wave tracking suppression and filtering modules. All Surge Protective Devices (SPD) systems shall be modular permanently connected, parallel designs. Series suppression elements shall not be acceptable. SPD system shall be a hybrid design utilizing thermally Protected Metal Oxide Varistors and Filter capacitors to suppress EMI/RFI electrical noise

B. The SPD shall be rated for 480/277VAC, three-phase, four-wire plug ground. The SPD system shall provide surge protection in all possible modes (L-N, L-G, L-L, and N-G). Each replaceable module shall provide the ability to deliver full surge current rating per mode.

1. Per Mode: 250 kA.
2. Per Phase: 500 kA.

C. The SPD shall provide EMI/RFI electrical noise attenuation of 36 to 44dB in the range of 50 kHz to 100 MHz.

D. Voltage Protection Ratings: The UL 1449 3rd Edition Voltage Protection Ratings "VPR" (6kV, 3000 Amps, 8/20μs waveform) shall not exceed the UL assigned values listed below:

1. L-L: 2000 V.
2. L-N, L-G, N-G: 1200 V.

E. The SPD shall have a minimum UL 1449 3rd Edition Nominal Discharge Current Rating (I_n) of 10,000 Amps.

F. Each individual module shall feature a green LED indicating the individual module has all surge protection devices active and a red LED indicating protective device is off-line.

G. Accessories shall include the following:

1. Form-C contacts, one normally open and one normally closed, for remote monitoring of system operation. Contacts to reverse position on failure of any surge diversion module.
2. Audible alarm activated on failure of any surge diversion module.

H. Six-digit transient-counter set to totalize transient surges that deviate from the sine-wave envelope by more than 125 V

I. Connect SPD leads into an unoccupied branch overcurrent device. Device shall be located immediately adjacent to the branch overcurrent device serving it. Factory leads shall not be extended or spliced, device must be installed in a manner to utilize the factory leads.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

C. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.

D. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

E. Install filler plates in unused spaces.

F. Stub eight 3/4-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 3/4-inch empty conduits into raised floor space or below slab not on grade.

G. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

H. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

1. Physical inspection and Testing

    a. Verify equipment rating correspond to drawings and specifications.
    b. Inspect the physical and mechanical condition and verify that it complies with manufacturer’s standards.
    c. Verify equipment is properly secured and aligned with the required clearances as specified in the drawings and specifications. Assure that the equipment is properly grounded.
    d. Verify that all packing materials have been removed and the equipment has been cleaned.
    e. Confirm all breaker sizes, quantities, and configurations correspond to the drawings and specifications.
    f. Confirm bolted and mechanical lug electrical connections are low impedance using one of the following means:
        1) Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar connections. Any similar resistance values that deviate more than 50 percent should be investigated.
        2) Inspect the bolted connection and verify that it is at the manufacturer’s rated torque using a calibrated torque wrench. If manufacturer’s data is not available verify the torque meets the requirements of Table 100.12 in the ANSI/NETA ATS-2009.
    g. A thermographic test shall be conducted. Equipment will be open at the time of the scan in order to get an accurate reading from the testing device. All equipment should be energized and loaded during test. Thermographic images of any connections that fail the test must be submitted with a description of the failure including the probable cause of the failure.

2. Electrical Inspection and Testing

a. Test each bus section for insulation resistance for one minute on phase to phase and phase to ground connections. Verify the test results comply with manufacturer's documentation or the requirements established in Table 100.1 of the ANSI/NETA ATS-2009.
b. Verify all meters functionality and accuracy after testing and calibrating all inputs.
c. Verify instrument transformers meet all the requirements of the drawings and specifications.
    1) Test transformer wiring integrity and proper transformer operation.
    2) Verify transformer output voltage is at the specified level.

3. Test Reports: Prepare a written report to record the following:

a. Test procedures used.
b. Test results that comply with requirements.
c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
d. Thermographic Test Report

B. Panelboards will be considered defective if they do not pass tests and inspections.

3.5 ADJUSTING

A. Set field-adjustable circuit-breaker trip ranges. Unless otherwise noted, trip settings shall mimic trip characteristics for thermal magnetic circuit-breakers of similar trip rating.

B. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.

1. Measure as directed during period of normal system loading.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

END OF SECTION 262416

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SECTION 262726 – WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes receptacles, connectors, floor boxes, switches, wall-box dimmers, and finish plates.

B. Related Sections include the following:
   1. Division 26 Section "Lighting Control Devices" for general purpose occupancy sensors.

1.3 DEFINITIONS

A. GFCI: Ground-fault circuit interrupter.

B. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

C. SPD: surge protection device.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Field quality-control test reports.

C. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.6 COORDINATION

A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
   1. Cord and Plug Sets: Match equipment requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Wiring Devices:
      a. Hubbell, Inc.; Wiring Devices Div.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand; Wiring Devices Div.
   2. Floor Boxes:
      a. Hubbell, Inc.; Wiring Devices Div.
      b. Wiremold/Legrand.
      c. Thomas and Betts Corporation.

2.2 STRAIGHT BLADE RECEPTACLES

A. General Purpose Receptacles: TAMPER-RESISTANT Heavy-Duty grade, rated 20A minimum. Comply with UL498.
   1. NEMA 5-20R (standard #WD1.101968).
   2. Arranged for back and side wiring.
   3. Grounding type. Separate single or double grounding terminals with screw lugs and a direct, green insulated conductor connector to system ground. Screw shall be green and hex-headed. Self-grounding type are not acceptable.
   4. Tamper Resistant
   5. Listed by an approved third party agency.

B. GFCI Receptacles: TAMPER RESISTANT Non feed-through type, with integral NEMA WD 6, Configuration 5-20R duplex. Design units for installation in a 2-3/4-inch- (70-mm-) deep outlet box without an adapter. Comply with UL 498 and UL 943, Class A. GFCI receptacles that are installed on the building exterior shall be weather resistant.

2.3 POP-UP COUNTERTOP RECEPTACLES

A. Pop-up Duplex Receptacle, Tamper Resistant
   1. 20A, 125V, Tamper-resistant NEMA 5-20 receptacles
   2. Circuit Rating: 20A non-feed through circuits
   3. Wiring Terminals: #12 AWG copper stranded or solid only
   4. 4. 4” diameter, die-cast aluminum, surface-mount trim/cover with brushed aluminum finish.
   5. Main Body: Thermoplastic PBT.
   6. Water Seals: Elastomers and Silicon
   7. Water-resistant (up to a half-gallon spill).
   8. Factory prepped for hard-wired installation (i.e. no plug).
   9. UL 498 Section 146 listed
   10. Pop-up operation rated for minimum of 10,000 cycles (open/close)

2.4 TWIST-LOCKING RECEPTACLES

A. Single Receptacles: Heavy-duty grade. Comply with NEMA WD 1, NEMA WD 6 for configuration as required, or as shown on plans, and UL 498.

2.5 FLOOR Boxes:

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling, or as indicated on plans.

C. Service Plate: Round, die-cast aluminum with satin finish.

D. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.

E. Data Communication Outlet: Blank cover is not being used or Two modular, keyed, color-coded, RJ-45 jacks for twisted pair cable complying with requirements in Section 267910.

2.6 POKE-THRU ASSEMBLIES

A. Description:

1. Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service-outlet assembly.
2. Comply with UL 514 scrub water exclusion requirements.
3. Service-Outlet Assembly: Flush type with two simplex receptacles and space for two RJ-45 jacks or quantities as indicated on plans. Complying with requirements in Section 267910.
4. Size: Selected to fit nominal 4-inch (100-mm) cored holes in floor and matched to floor thickness.
5. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
6. Closure Plug: Arranged to close unused 4-inch (100-mm) cored openings and reestablish fire rating of floor.
7. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of four, four-pair cables that comply with requirements in Section 267910.

B.

2.7 SWITCHES

A. General Purpose Snap Switches: Heavy-duty, quiet type. Comply with NEMA WD1 and UL 20.
1. 20A, 120/277v, AC only.
2. Grounding type, with green hex-head grounding screw.
3. Quiet type operating mechanism; shall not utilize mercury switches.
4. Listed by an approved third party agency.

B. Equipment Disconnect Snap Switches: Heavy-duty, quiet type. Comply with NEMA WD1 and UL 20.
1. 30A, 120/277v, AC only.
2. Grounding type, with green hex-head grounding screw.
3. Quiet type operating mechanism; shall not utilize mercury switches.
4. Listed by an approved third party agency.

C. Keyed Snap Switch, 120/277 V, 20A
1. Description: Heavy Duty Industrial Grade, Locking Toggle Switches, Single Pole, 20A 120/277V AC, Back and Side Wired, Key Guide/Slot (in place of toggle). All switches provided shall be keyed alike and from the same manufacturer. 1, 3, & 4-way operation where indicated.

D. Key-Operated Switches, 120/277 V, 20 A:

1. Description: Single pole, with cam (tumbler type) lock in lieu of switch handle. All switches provided shall be keyed alike with factory-supplied key. Key can be removed in either position, no captive key type switches.
2. For Science Classrooms

E. Pilot Light Toggle Switch, 120/277 V, 20 A:
1. Description: Industrial Grade, Pilot Light Toggle Switches, Single Pole, 20A 120/277V AC, Back and Side Wired, Red Illuminated Toggle. Pilot light on while load on.

F. Pilot Light (No Toggle Switch_, 120/277 V, 20 A:
1. Description: Industrial Grade, Pilot Light (fits standard Toggle Switch cover opening), Single Pole, 20A 120/277V AC, Back and Side Wired, Red Illuminated Pilot Light. Pilot light on while load on.

G. 0-10V Dimming Occupancy Sensor Switch (OSD)
1. Basis of design: #MS-Z101-V
2. Description: Industrial Grade, fits standard decorative cover opening, Single or Three way with companion, 8A, 120/277V AC, Back and Side Wired, XCT PIR Sensing, vacancy only sensor mode, minimum of 900 sq ft of coverage.

H. 0-10V Dimming Switch, On/Off (D or 3D)
1. Basis of design #DVSTV
2. Description: Commercial Grade, fits standard decorative cover opening, Single or Three way, 8A, 120/277V AC, Back and Side Wired, 10 year life expectancy minimum,

I. Standard Occupancy Sensor Switch (OS)
1. Vacancy sensor switch, Sensor LED, Dual Technology, adjustable timeout settings, fits with standard decora style plate

2.8 WALL PLATES

A. Single and combination types to match corresponding wiring devices.
1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.04-inch (1-mm) thick, Type 302, satin-finished stainless steel.
3. Material for Unfinished Spaces:
   a. Flush Boxes: Same as finished spaces.
   b. Surface-mount boxes: Galvanized steel with crushed corners, sized for wiring device installed. Mud-ringstyle, raised covers not allowed where boxes are exposed. Stacked covers or protruding edges are not allowed.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."

B. Wet-Location, Weatherproof Cover Plates (Receptacles): “In Use” cast aluminum with cover capable of closing with plug assembly still engaged, gasketed, and listed and labeled for use in “wet locations.” Cover shall be deep type for commercial usage (minimum 3” depth).

C. Wet-Location, Weatherproof Cover Plates (Toggle Switches): Gasketed, listed and labeled for use in “wet locations.” Cover shall be lever type with full switch coverage. Toggle operates via a fork on the interior of the cover. In-use covers or rubber type toggle cover are not allowed.

2.9 FINISHES

A. Color:

1. Wiring Devices Connected to Normal Power System: White, unless otherwise indicated or required by NFPA 70 or device listing.
2. Receptacle Devices Connected to Stand-by Power System: Green, unless otherwise indicated or required by NFPA 70 or device listing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Coordination with Other Trades:
1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:
1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
   a. Cut back and pigtail, or replace all damaged conductors.
   b. Straighten conductors that remain and remove corrosion and foreign matter.
   c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:
1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:
1. Mount vertically except where installed over counters, back-splashes, etc. mount horizontally.

2. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
   a. Provide 2% quantity of spare cover plates of each type to Owner.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

3.2 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Test wiring devices for proper polarity and ground continuity. Operate each device at least six times.

B. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.

C. Replace damaged or defective components.

3.4 CLEANING

A. Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

END OF SECTION 26 27 26

SECTION 262813 – FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Cartridge fuses rated 600-V ac and less for use in enclosed switches and controllers.
   2. Spare-fuse cabinets.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

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. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

1.5 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

1.6 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than six of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. 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:
1. Cooper Bussmann, Inc.
2. Edison Fuse, Inc.
3. Ferraz Shawmut, Inc.
4. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

2.3 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
1. Size: Adequate for storage of spare fuses specified with 20 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.
4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

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

3.2 FUSE APPLICATIONS

A. Feeders: Class RK1, UL listed, current limiting, 200kA interrupting rating.

B. Motor and Motor Controller Branch Circuits: Class RK5, UL listed, current limiting time delay, 200 kA interrupting rating.

C. Other Individual Equipment Branch Circuits: Class RK5, UL listed, non-time delay, 50 kA interrupting rating.

3.3 INSTALLATION

A. Fuses shall be selected as to provide a fully selective system.

B. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

C. Install spare-fuse cabinet in main mechanical room.

3.4 IDENTIFICATION

A. Install labels indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813

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SECTION 26 28 16 – ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes individually mounted enclosed switches and circuit breakers used for the following:
   1. Feeder and branch-circuit protection.
   2. Motor and equipment disconnecting means.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
   1. Enclosure types and details for types other than NEMA 250, Type 1.
   2. Current and voltage ratings.
   3. Short-circuit current ratings (interrupting and withstand, as appropriate).
   4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

C. Field quality-control reports.
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

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. Comply with NFPA 70.

1.6 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Fusible Switches:
      a. Eaton Corp.; Cutler-Hammer Products.
      b. General Electric Co.; Electrical Distribution & Control Division.
      c. Siemens Energy & Automation, Inc.
      d. Square D Co.
   2. Molded-Case Circuit Breakers:
      a. Eaton Corp.; Cutler-Hammer Products.
      b. General Electric Co.; Electrical Distribution & Control Division.
      c. Siemens Energy & Automation, Inc.
      d. Square D Co.

2.2 ENCLOSED SWITCHES

A. All Switches:
   1. Heavy Duty type with nonteasible, positive, quick make-quick break mechanisms.
   2. Handles whose positions are easily recognizable and are padlockable in either the “on” or “off” positions.
   3. Defeatable door interlocks that prevent the door from opening when the operating handle is in the “on” position.

B. Enclosed, Nonfusible Switch: NEMA KS 1, Type HD, with lockable handle.

C. Enclosed, Fusible Switch, 800 A and Smaller: NEMA KS 1, Type HD, with clips to accommodate specified fuses, lockable handle with two padlocks.
   1. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.

2.3 MOLDED-CASE CIRCUIT BREAKERS

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with full interrupting capacity to meet available fault currents.

1. Electronic Trip Circuit Breakers: Electronic trip circuit breakers with RMS sensing; field-replaceable rating plug or field-replicable electronic trip and individually field-adjustable long time, short time, and instantaneous trip pickup level settings. Trip unit shall also have adjustable long time and short time delay settings. Provide for circuit-breaker frame sizes 250A and larger.
2. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Field adjustable instantaneous trip setting for circuit-breaker frame sizes 100 A to 225A.

B. Breakers Serving Transfer Switches: Type and Frame size as required to meet “Specific Coordinated Molded Case Breaker” as required by submitted automatic transfer switch for a minimum 42,000 A withstand rating.

C. Features and Accessories:
1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

2.4 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 4X.
3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4X.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

C. Install fuses in fusible devices.

D. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

B. Testing Technician
   1. The testing technicians shall be trained in all the methods of correctly and safely conducting the required test. The technician shall have regular experience conducting the required tests and they must have the knowledge to determine the serviceability of a specific piece of equipment.

C. Physical Inspection and Testing
   1. Verify equipment rating correspond to drawings and specifications.
   2. Inspect the physical and mechanical condition and verify that it complies with manufacturer's standards.
   3. Verify equipment is properly secured and aligned as specified in the drawings and specifications.
   4. Verify the equipment is clean.
   5. Open and close circuit breaker to verify smooth and proper operation.
   6. Confirm bolted electrical connections are low impedance using one of the following means:
      a. Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar connections. Any similar resistance values that deviate more than 50 percent should be investigated.
      b. Inspect the bolted connection and verify that it is at the manufacturer's rated torque using a calibrated torque wrench. If manufacturer's data is not available verify the torque meets the requirements of Table 100.12 in the ANSI/NETA ATS-2009.

D. Electrical Inspection and Testing
   1. Test the insulation resistance on each pole. The resistance should be measured from phase to phase and phase to ground while the breaker is engaged. When the switch is not engaged the insulation resistance should be measured across each pole. For testing purposes apply a voltage as recommended by the manufacturer. If no recommendations are available from the manufacturer refer to Table 100.1 in the ANSI/NETA ATS-2009.

E. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

F. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

G. Remove and replace units that do not pass tests and inspections and retest as specified above.

H. Test Reports: Prepare a written report to record the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

END OF SECTION 262816

SECTION 263213 – PACKAGED ENGINE GENERATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes packaged diesel engine generator set with the following features and accessories:
1. Engine generator set (optional standby).
2. Base mounted diesel fuel tank with spill containment.
3. Battery charger/starting battery.
4. Jacket water heater.
5. Output circuit breaker (permanent load).
6. Output circuit breaker (temporary load bank).
7. Outdoor generator set enclosure.
8. Generator platform, stairs and guard rail system.
9. Remote annunciator.
10. Remote EPO station.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Deliver engine generator set and system components to their final locations in protective wrappings, containers, and other protection that will exclude dirt and moisture and prevent damage from construction operations. Remove protection only after equipment is safe from such hazards.

1.4 COORDINATION

A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases.

PART 2 - PRODUCTS (FURNISHED UNDER A SEPARATE CONTRACT)

2.1 GENERATOR PLATFORM

A. Provide Generator Work platform for General access and Maintenance as detailed in drawings.
1. Platform shall be aluminum or approved corrosive metal construction with non-slip walkway surfaces.
2. Platform shall be at length shown with steps increments as shown on drawings.
3. Provide kick plates on platform top level and 42” minimum handrails for one side of stairs and platform.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment foundations, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.

B. Examine roughing-in of electrical connections. Verify actual locations of connections before packaged engine generator installation.

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

3.2 CONCRETE BASES

A. Install concrete bases of dimensions indicated for packaged engine generators. Refer to Division 3 Section "Cast-in-Place Concrete" and Division 26 Section "Basic Electrical Materials and Methods".

3.3 INSTALLATION

A. Comply with packaged engine generator manufacturers' written installation and alignment instructions, and with NFPA 110.

B. Set packaged engine generator set on concrete bases.
1. Support generator-set mounting feet on rectangular metal blocks and shims or on metal wedges having small taper, at points near foundation bolts to provide 3/4- to 1-1/2-inch gap between pump base and foundation for grouting.
2. Adjust metal supports or wedges until generator is level.

C. Install packaged engine generator to allow access for periodic maintenance, including removal of drivers and accessories.

D. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.
1. Verify that electrical wiring is installed according to manufacturers' submittal and installation requirements in Division 26 Sections. Proceed with equipment startup only after wiring installation is satisfactory.

3.4 CONNECTIONS

A. Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:
1. Connect fuel piping to engines with flexible fuel lines.
2. Connect exhaust-system piping to engines.

B. Ground equipment according to Division 26 Section "Grounding and Bonding."

C. Connect wiring according to Division 26 Section "Conductors and Cables."

3.5 IDENTIFICATION

A. Identify system components according to Division 26 Section "Identification for Electrical Systems."

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections, and to assist in testing. Report results in writing.

B. Testing Technician
   1. The testing technicians shall be trained in all the methods of correctly and safely conducting the required test. The technician shall have regular experience conducting the required tests and they must have the knowledge to determine the serviceability of a specific piece of equipment.

C. Physical Inspection and Testing
   1. Verify equipment rating correspond to drawings and specifications.
   2. Inspect the physical and mechanical condition and verify that it complies with manufacturer's standards.
   3. Verify equipment is properly secured and aligned and grounded as specified in the drawings and specifications.
   4. Verify the equipment is clean.
   5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
   6. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at distances specified for enclosure and at nearest point along property line. Compare measured levels with required values and issue report.

D. Electrical Inspection and Testing
   1. Test the insulation resistance with the guidelines established in the ANSI/IEEE Standard 43. If the engine is 200 HP or less the test shall last one minute otherwise the test shall last ten minutes. The polarization should not be less than 1 and the insulation resistance of most engines is 5 mega-ohms.
   2. Test the generator control systems and verify that it shuts the generator down when an alarm is triggered.
   3. Test the equipment vibration according to manufacturer's recommendations.
   4. Performs tests consistent with the guidelines in ANSI/NFPA 110 and manufacturer's standards.
   5. Verify functionality of the governor and regulator.
   6. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
   7. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
      1. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
      2. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
      3. Verify acceptance of charge for each element of the battery after discharge.
      4. Verify that measurements are within manufacturer's specifications.
   8. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.

E. Load Bank Testing: Prior to acceptance of the installation, the generator shall be subjected to a four hour load bank test. This test shall be performed at the job site in the presence of an Owner's representative. Test shall include continuous operation of generator set at 50% load for one hour, 75% for next hour, and 100% for final two hours. Upon completion of the four hour test, the generator shall be shut-down after the cool down period. Next the generator shall be started and immediately upon reaching rated speed, 100% percent load shall be applied to demonstrate one step full load capability. The capability of the system to pick up full standby service load with 10 second of power outage shall also be demonstrated. After testing is complete:
   1. A full tank of fuel shall be provided, replacing any fuel used for testing. Diesel fuel shall be treated with an alcohol-free additive to disperse water and clean injectors.

2. Copy of the generator's load test report shall be sent to the Designer and the Owner.

F. Coordinate tests with tests for transfer switches and run them concurrently.

G. Coordinate testing with Wake county personnel on installation, connection, and demonstration of County owned SCADA system. Obtain completion of installation from County representative prior to final acceptance.

H. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.

I. Fuel Tank Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

J. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Functional testing shall include entire system including:
1. New ATS.
2. New Generator.
3. **New** SCADA system.

K. Remove and replace malfunctioning units and retest/reinspect as specified above.

L. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.
1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation and thermal photograph of deficiencies detected, remedial action taken, and observations with thermal photograph after remedial action demonstrating resolution.

M. Attach a label or tag to each tested component indicating satisfactory completion of tests.

N. Test Reports: Prepare a written report to record the following:
1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
4. Insulation Resistance
5. Time Delays.

3.7 CLEANING

A. On completion of installation, inspect system components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Clean components internally using methods and materials recommended by manufacturer.

3.8 GENERATOR TURNED OVER TO OWNER

A. Contractor is responsible for all fuel and maintenance costs for operation of generator prior to Substantial Completion, including all testing and inspections. After all testing is complete, Contractor shall re-fill fuel tank to full level.

B. After Substantial Completion, but not more than 30 days after Final Acceptance, Contractor shall have generator serviced by a factory-authorized service technician. Service shall include replacement of air and oil filter. All components of generator system shall be inspected and replaced if defective.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators as specified below:
1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data".
3. Coordinate this training with that for transfer switches.
4. Schedule training with Owner, through Architect, with at least ten days' advance notice.
5. Minimum Instruction Period: Four hours.

END OF SECTION 263213

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SECTION 263323 – CENTRALIZED EMERGENCY LIGHTING INVERTER

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes uninterruptible power supply type centralized emergency lighting inverters with a microprocessor controlled pulse-width-modulated (PWM) inverter, high speed transfer devices, constant voltage regulating transformer, battery charging system, batteries, and integral monitoring display panel.

1.3 DEFINITIONS

A. THD: Total harmonic distortion.

B. UPS: Uninterruptible power supply.

1.4 SUBMITTALS

A. Product Data: For all inverter system components, including, but not limited to UPS, battery charger, and batteries.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.

1. Wiring Diagrams: Detail internal and interconnecting wiring; and power, signal, and control wiring.
2. Elevation and details of control and indication displays.
3. Output distribution section.

C. Manufacturer Certificates: For each product, from manufacturer.

D. Field quality-control test reports.

E. Performance Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.

F. Operation and Maintenance Data: For central battery inverter equipment to include in emergency, operation, and maintenance manuals.

G. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Central Battery Inverter System: UL 924 listed.

C. Comply with NFPA 70, NFPA 101, and NFPA 111.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment in fully enclosed vehicles.

B. Store equipment in spaces having environments controlled within manufacturers' written instructions for ambient temperature and humidity conditions for non-operating equipment.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace batteries that fail in materials or workmanship within specified warranty period. Special warranty, applying to batteries only, applies to materials only, on a prorated basis, for period specified.

1. Warranty Period for Sealed Valve-Regulated, Lead-Calcium Batteries:

a. Full Warranty: Five years.
b. Pro Rata: Nine years following one year of full warranty.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Isolite- E3MAC-Single Phase
2. Myers Emergency Power Systems – Illuminator Series
3. Sure-Lites – INV-I-S Series

2.2 INVERTER PERFORMANCE REQUIREMENTS

A. Uninterruptible Power Supply (UPS) Type Emergency Lighting Inverters: Continuously provide ac power to connected electrical system.

1. Automatic Operation includes the following:

a. Normal Conditions: Supply the load with ac power flowing from normal ac power input terminals, through rectifier-charger and inverter, with battery connected in parallel with rectifier-charger output.

b. Abnormal Supply Conditions: If normal ac supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, battery supplies constant, regulated, inverter ac power output to the load without switching or disturbance.
c. If normal power fails, battery continues supply-regulated ac power through the inverter to the load without interruption of power or any disturbance.
d. When power is restored at normal supply terminals of system, controls automatically synchronize inverter with the external source before transferring the load. Rectifier-charger then supplies power to the load through the inverter and simultaneously recharges battery.
e. If battery becomes discharged and normal supply is available, rectifier-charger charges battery. When battery is fully charged, rectifier-charger automatically shifts to float-charge mode.
f. If any element of central battery inverter system fails and power is available at normal supply terminals of system, static bypass transfer switch transfers the load to normal ac supply circuit without disturbance or interruption of supply.
g. If a fault occurs in system supplied by central battery inverter and current flows in excess of the overload rating of central battery inverter system, static bypass transfer switch operates to bypass fault current to normal ac supply circuit for fault clearing.
h. When fault has cleared, static bypass transfer switch returns the load to central battery inverter system.
i. If battery is disconnected, central battery inverter continues to supply power to the load with no degradation of its regulation of voltage and frequency of output bus.

B. Output Load Capacity: Rated in KVA at 1.0 (unity) power factor. Refer to plans for size.

C. Overload Capability: 125% for ten minutes.

D. Surge Capability: 150% of rated output without need of static bypass.

E. Frequency Stability: ± 0.2 Hz.

F. Efficiency: Not less than 89% under full rated load.

G. Maximum Acoustical Noise: 50dB, "A" weighting, emanating from any UPS component under any condition of normal operation, measured 39 inches (990 mm) from nearest surface of component enclosure.

2.3 SERVICE CONDITIONS

A. Environmental Conditions: Inverter system shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Ambient Temperature for Electronic Components: 32 to 105 deg F (0 to 40 deg C).
2. Relative Humidity: 0 to 95 percent, noncondensing.
3. Altitude: Sea level to 4000 feet (1220 m).

B. Physical Limitations: Centralized emergency lighting inverter is shown on plans for installation in restricted/limited space. Maximum dimensions of equipment, including both UPS and battery cabinets where separate, are the following:

1. Maximum width: 32” wide.
2. Maximum depth: 25” deep.

2.4 INVERTERS

A. Description: Solid-state pulse-width-modulated (PWM) type, with the following operational features:

1. AC Input:

a. Input Voltage: 277 VAC, single-phase, two-wire plus ground.
b. Input Voltage Operating Range: +10% to -15%.
c. Frequency: 60 Hz, ±3 Hz.
d. Surge Protection: Compliant with ANSI C62.41 (IEEE 587).
e. Provide integral main circuit breaker protection on AC input.

2. AC Output

a. Output Voltage: 277 VAC, single-phase, two-wire plus ground.
b. Output Voltage Regulation: ± 3%.
c. Output Harmonic Distortion: Less than 5% under linear load, Less than 10% total under all listed loads.
d. Frequency Regulation: ± 1 Hz, from no load to full load at unit power factor over the operating range of battery voltage.
e. Provide integral main output circuit breaker and, unless otherwise noted on schedules, provide a minimum of four (4) 20A/1P branch output circuit breakers.

3. Output Protection: Current-limiting and short-circuit protection.

2.5 BATTERY CHARGER

A. Description: Solid-state full wave, three-stage, filtered, automatically maintaining batteries in fully charged condition when normal power is available. With LED indicators for "float" and "high-charge" modes. Recharge time UL 924, NFPA 101, and NFPA 111 compliant.

2.6 BATTERIES

A. Description: Integral, valve-regulated, sealed, maintenance free lead calcium batteries.

1. Operating Time: Minimum 90 minutes at full rated kilowatt output capability, UL 924 Compliant.

2. Battery Cell Voltages: 2.27 V per cell float, 1.75 V per cell final.

3. Battery Life: Expected service life of 10 years.

2.7 ENCLOSURES

A. NEMA 250, Type 1 steel cabinets with access to components through hinged doors with flush tumbler lock and latch.

B. Finish: Manufacturer's standard baked-enamel finish over corrosion-resistant prime treatment.

C. Input and Output Breakers shall be mounted through door or behind a dead-front cover such that they are operable without exposing user to live conductors.

2.8 CONTROL AND INDICATION

A. Description: Group displays, indications, and basic system controls on common control panel on front of central battery inverter enclosure.

B. Minimum displays, indicating devices, and controls shall include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms shall include an audible signal and a visual display.

C. Indications: Plain-language messages on a digital LCD.

1. Quantitative Indications:

a. Input voltage, each phase, line to line.
b. Input current, each phase, line to line.
c. System output voltage, each phase, line to line.
d. System output current, each phase.
e. System output frequency.
f. DC bus voltage.
g. Battery current and direction (charge/discharge).
h. Elapsed time-discharging battery.

2. Basic Status Condition Indications:

a. Normal operation.
b. Load-on bypass.
c. Load-on battery.
d. Inverter off.
e. Alarm condition exists.

3. Alarm Indications:

a. Battery system alarm.
b. Control power failure.
c. Fan failure.
d. Overload.
e. Battery-charging control faulty.
f. Input overvoltage or undervoltage.
g. Approaching end of battery operation.
h. Battery undervoltage shutdown.
i. Inverter fuse blown.
j. Inverter transformer overtemperature.
k. Inverter overtemperature.
l. Static bypass transfer switch overtemperature.
m. Inverter power supply fault.
n. Inverter output overvoltage or undervoltage.
o. System overload shutdown.
p. Inverter output contactor open.
q. Inverter current limit.

4. Controls:

a. Inverter on-off.
b. Start.

c. Battery test.
d. Alarm silence/reset.
e. Output-voltage adjustment.

D. Dry-form "C" contacts shall be available for remote indication of the following conditions:

1. Inverter on battery.
2. Inverter on-line.
3. Inverter load-on bypass.
4. Inverter in alarm condition.
5. Inverter off (maintenance bypass closed).

2.9 MAINTENANCE BYPASS

A. Maintenance Bypass/Isolation Switch: Switch is interlocked so it cannot be operated unless static bypass transfer switch is in bypass mode. Switch provides manual selection among the following three conditions without interrupting supply to the load during switching:

1. Full Isolation: Load is supplied, bypassing central battery inverter system. Normal ac input circuit, static bypass transfer switch, and central battery inverter load terminals are completely disconnected from external circuits.
2. Maintenance Bypass: Load is supplied, bypassing central battery inverter system. Central battery inverter ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
3. Normal: Normal central battery inverter ac supply terminals are energized and the load is supplied either through static bypass transfer switch and central battery inverter rectifier-charger and inverter or through battery and inverter.

2.10 SYSTEM MONITORING AND ALARMS

A. Remote Status and Alarm Panel in compliance with NFPA 111 remote annunciation: Labeled LEDs on panel faceplate shall indicate basic status conditions of normal power, battery power, low-battery, fault/alarm, battery output voltage, system output voltage, each leg, system output current, each leg, system output frequency, and internal battery temperature. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.

1. Cabinet and Faceplate: Flush mounted to suit mounting conditions indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment will be installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

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

3.2 INSTALLATION

A. Install system components on concrete base and attach by bolting.

1. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 3 inches (75 mm) in all directions beyond the maximum dimensions of switchgear unless otherwise indicated or unless required for seismic anchor support. Construct concrete bases according to Division 26 Section "Basic Electrical Materials and Methods."
2. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
4. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete"

B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.3 CONNECTIONS

A. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams, unless otherwise indicated.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

1. Separately Derived Systems: Make grounding connections to grounding electrodes and bonding connections to metallic piping systems as indicated; comply with NFPA 70.

3.4 IDENTIFICATION

A. Identify equipment and components according to Division 26 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Testing Technician

1. The testing technicians shall be trained in all the methods of correctly and safely conducting the required test. The technician shall have regular experience conducting the required tests and they must have the knowledge to determine the serviceability of a specific piece of equipment.

B. Physical Inspection and Testing

1. Verify equipment rating correspond to drawings and specifications.
2. Inspect the physical and mechanical condition and verify that it complies with manufacturer’s standards.
3. Verify equipment is properly secured and aligned and grounded as specified in the drawings and specifications.
4. Verify the equipment is clean.

5. Confirm bolted electrical connections are low impedance using one of the following means:

    a. Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar connections. Any similar resistance values that deviate more than 50 percent should be investigated.
    b. Inspect the bolted connection and verify that it is at the manufacturer's rated torque using a calibrated torque wrench. If manufacturer's data is not available verify the torque meets the requirements of Table 100.12 in the ANSI/NETA ATS-2009.

C. Electrical Inspection and Tests

1. Test the equipment's transferring capabilities for correct operation.
2. Verify controls function according to manufacturer's standards and verify that any alarms trigger properly. Test the synchronization indicators for static and bypass switches.

D. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

E. Tests and Inspections:

1. Inspect interiors of enclosures for integrity of mechanical and electrical connections, component type and labeling verification, and ratings of installed components.
2. Test manual and automatic operational features and system protective and alarm functions.
3. Test communication of status and alarms to remote monitoring equipment.
4. Perform installation acceptance testing per NFPA 111, Section 7.6, including load bank full load and building load tests. The following SEPSS documentation shall be on-hand for AHJ review:
    a. Factory test data on the completed system
    b. Battery specifications
    c. Manufacturer's certificate of compliance to the specification.

F. Remove and replace malfunctioning units and retest as specified above.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Verify that central battery inverter is installed and connected according to the Contract Documents.

C. Complete installation and startup checks according to manufacturer's written instructions.

3.7 CLEANING

A. On completion of installation, inspect interior and exterior of cabinets. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

B. Install new filters in each equipment cabinet within 14 days from date of Substantial Completion.

3.8 DEMONSTRATION

Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain emergency lighting inverters. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 263323

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SECTION 263600 – TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes transfer switches rated 600 V and less, including the following:

1. Automatic transfer switches.

1.3 SUBMITTALS

A. Field quality-control test reports.

1.4 COORDINATION

A. Specific Coordinated Breaker: Where required to meet specified fault-current closing and withstand ratings, coordinate manufacturer and type of specific coordinated breaker with products provided under Division 26 Section “Switchboards” and “Panelboards.”

PART 2 - PRODUCTS (FURNISHED UNDER A SEPARATE CONTRACT)

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install surface-mounted enclosures on 12 gauge formed steel channel having a cross-sectional dimension of at least 1-1/2” x 1-1/2”. The channel and fittings shall have hot-dipped galvanized finish. Channels may be installed vertically or horizontally.

B. Identify components according to Division 26 Section "Identification for Electrical Systems."

C. Set field-adjustable intervals and delays.
1.
2. Engine Start Time Delay: Set for 3 seconds.
3. Transfer Normal to Emergency Time Delay:
   a. Emergency ATS: Set for 0 seconds.
   b. Stand-by ATS: Set for 10 seconds.
4. Retransfer Emergency to Normal Source Time Delay: Set for 5 minutes.
5. Engine Shutdown Time Delay: Set for 5 minutes.

3.2 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
   1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.

B. Testing Technician
   1. The testing technicians shall be trained in all the methods of correctly and safely conducting the required test. The technician shall have regular experience conducting the required tests and they must have the knowledge to determine the serviceability of a specific piece of equipment.

C. Physical Inspection and Testing
   1. Verify equipment rating correspond to drawings and specifications.
   2. Inspect the physical and mechanical condition and verify that it complies with manufacturer's standards.
   3. Verify equipment is properly secured and aligned and grounded as specified in the drawings and specifications.
   4. Verify the equipment is clean.
   5. For all moving electrical parts verify that proper lubrication has been applied so that they can be operated in a smooth motion.
   6. Verify that equipment warnings and labels are clearly identified.
   7. Confirm bolted electrical connections are provided with high impedance using one of the following means:
      a. Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar connections. Any similar resistance values that deviate more than 50 percent should be investigated.
      b. Inspect the bolted connection and verify that it is at the manufacturer's rated torque using a calibrated torque wrench. If manufacturer's data is not available verify the torque meets the requirements of Table 100.12 in the ANSI/NETA ATS-2009.

D. Electrical Inspection and Testing
   1. Test the resistance across the switching device including the contacts and poles. Gathered data shall not exceed manufacturer's recommended values for normal operation if the manufacturer does not provide recommended values all switches that vary more than 50 percent of the lowest value should be investigated.
   2. Verify controller is functioning according to manufacturer's recommendations as well as the requirements of the drawings and specifications.
   3. Simulate the following power states in order to test automatic transfer switch operation.
      a. A loss of normal power.
      b. Re-energize normal power.
      c. A loss of emergency power.
   4. Test the following automatic transfer switch features or devices.
      a. The normal and emergency source sensing capabilities.
      b. Sequence of operations upon engine start-up.
      c. Verify the time delay prior to transition.
      d. Automatic transfer.
      e. Sequence of operations upon engine shut-down.
   5. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages

and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

a.

b. Check for electrical continuity of circuits and for short circuits.

c. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.

d. Verify that manual transfer warnings are properly placed.

e. Perform manual transfer operation.

E. Remove and replace units that do not pass tests and inspections and retest as specified above.

F. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

3.3 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 263600

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SECTION 26 36 01 – MANUAL TRANSFER SWITCH

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes a 3-way manual transfer switch for the purpose of permanent switching means to connect a portable generator or load bank to a single emergency generator source, with the following features and accessories:
   1. Mechanically interlocked, three (3) 3-pole molded case switch type manual transfer switches in a single enclosure.
   2. NEMA 3R enclosure (wall mount or padmount).
   3. Cam locks for loadbank and portable generator connections.
   4. Remote alarm contact.
   5. Phase rotation and system bonding requirements signage.

1.3 QUALITY ASSURANCE

A. 3-way manual transfer assembly switch shall be UL listed and labeled under the UL 1008 standard.

B. 3-way manual transfer switch manufacturer shall provide a complete factory assembled, wired and tested 3-way manual transfer switch.

C. 3-way manual transfer switch shall be factory Hi-pot tested for a period of not less than 60 seconds.

D. 3-way manual transfer switch installation shall meet all applicable NEC standards.
   1. 2020 NEC 700.3 (F) compliant when used in conjunction with an ATS.

1.4 SUBMITTALS

A. Contractor shall submit manufacturer’s drawings and data of manual transfer switches for Engineer’s approval prior to start of fabrication. Drawings and data shall include, as a minimum, dimensioned general arrangement drawings and wiring diagrams, UL listing information including UL file or control number, short circuit rating or withstand rating, component data, mounting provisions, conduit entry locations and installation instructions.

B. Upon installation of manual transfer switches Contractor shall submit manufacturer’s Operating & Maintenance Manual which shall include as a minimum:
   1. Certified as-built General Arrangement drawings and Wiring Diagram.
   2. Materials / Component List including part numbers.
   3. Maintenance and service requirements.

4. Certificate of Compliance and hi-pot test data.

1.5 WARRANTY

A. 3-way manual transfer switches shall be covered by manufacturer's warranty for a minimum period of (1) one year after shipment from manufacturer.

PART 2- PRODUCTS

2. 1 GENERAL

A. All equipment shall be new.

B. 3-way manual transfer switch manufacturer must have produced and sold UL 1008 Listed manual transfer switches as a standard product for a minimum of (3) years.

C. 3-way manual transfer switches shall be molded case switch type; knife switch or fused switches are not acceptable.

D. Contractor shall be responsible for the equipment until it has been installed and is finally inspected, tested and accepted in accordance with the requirements of this Specification.

E. 3- way manual transfer switches shall be TripleSwitch as manufactured by ESL Power Systems, Inc. or equal as approved by the Engineer.

2.2 3-WAY MANUAL TRANSFER SWITCHES

A. 3-way manual transfer switch shall consist of (3) mechanically-interlocked molded case switches, male cam-style inlet connectors, female cam-style outlet connectors, power distribution blocks and grounding terminals, all housed within a padlockable enclosure.

B. 3-way manual transfer switch enclosure shall be Type 3R, constructed of continuous seam-welded, powder coated galvanneal steel. The main access shall be through an interlocked, hinged door that extends the full height of the enclosure. Access for both portable generator cables with female cam-style plugs and for load bank cables with male cam-style plugs shall be via a) drawn flange cable entry openings in the bottom of enclosure for wall mount units, or b) hinged lower door for pad mount units. A hinged flap door shall be provided to cover the cable openings when cables are not connected; the hinged flap door shall allow cable entry only after the main access door has been opened. Enclosure shall be powder coated after fabrication; color shall be wrinkle gray RAL 7035.

C. Cam-style male connectors (inlets) and cam-style female connectors (outlets) shall be UL Listed single-pole separable type and rated 300 amps at 600VAC. All cam-style connectors shall be color coded. Cam-style connectors shall be provided for each phase and for ground, and shall also be provided for neutral. Each of the phase cam-style connectors and the neutral cam-style connectors within the enclosure shall be factory-wired to a molded case switch. The ground cam-style male connectors shall

be bonded to the enclosure, and a ground lug shall be provided for connection of the facility ground conductor. None of the cam-style connectors shall be accessible unless all (3) molded case switches are in the "OFF" position and the main access door is open.

D. A power distribution block shall be provided for load-side field wiring. The power distribution block shall be factory wired to the molded case switches.

E. Molded case switches shall be UL Listed 3-pole and the short circuit interrupt rating shall be a minimum of 10kAIC at 480VAC. Rating of the molded case switches shall be as shown on the drawings. One molded case switch shall control the connection between the permanent generator and the automatic transfer switch. The second switch shall control the connection between the permanent generator and the load bank female cam-style connectors. The third switch shall control the connection between the automatic transfer switch and the portable generator male cam-style connectors. All (3) molded case switches shall include UL Listed door-mounted operating mechanisms, preventing the opening of the main access door unless all (3) breakers are in the "OFF" position. All (3) molded case switches shall be mounted behind a deadfront panel. The load-side of the molded case switches shall not be energizable unless the main access door is closed and one of the molded case switches is in the "ON" position. The (3) molded case switches shall be safety interlocked by mechanical means to ensure that only certain breakers can be closed at any given time.

F. DPDT, 600VAC, 6A rated dry remote alarm contacts per NEC 700.3.F shall be included to allow remote annunciation whenever permanent generator power source is disconnected. Contractor shall provide controls wiring back to Division 23 BAS system. Provide warning label near permanent label switch, "Disconnection of permanent generator will cause alarm."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Prior to installation of 3-way manual transfer switches, Contractor shall examine the areas and conditions under which the 3-way manual transfer switch is to be installed and notify the Engineer in writing if unsatisfactory conditions exist.

B. 3-way manual transfer switch shall be installed as shown on the drawings and per the manufacturer's written instructions. In addition, the installation shall meet the requirements of local codes, the National Electrical Code and National Electrical Contractors Association's "Standard of Installation".

C. Conduit entry into the 3-way manual transfer switch shall be by Contractor; Contractor shall furnish and install listed watertight conduit hubs, as manufactured by MYERS or T&B, for each conduit entry on the 3-way manual transfer switch. The incoming hub size shall match the conduit size for feeders and ground as shown on the drawings. The outgoing hub size shall match the conduit size for loads and ground as shown on the drawings. Hubs shall be properly installed and tightened to maintain Type 3R integrity of the 3-way manual transfer switch enclosure.

D. Contractor shall terminate feeder conductors, load conductors and ground per the manufacturer's instructions. All field wiring terminations shall be torqued as required per the instructions on the 3-way manual transfer switch's power distribution blocks, switches & ground lugs.

E. Provide warning sign(s) at the portable generator connection point marked with system phase rotation and system bonding requirements.

3.2 FIELD TESTING

A. Prior to energizing 3-way manual transfer switch, the Contractor shall perform the following checks and tests as a minimum:
    1. Verify mounting and connections are complete and secure.
    2. Verify internal components and wiring are secure.
    3. Perform continuity check of all circuits.
    4. Perform 1,000 VDC megger test on feeder, load and ground cables.
    5. Verify deadfront is secure.
    6. With the 3-way manual transfer switch deadfront in place and the main access door closed and properly latched, actuate all (3) Operator Mechanisms; verify:
        a. With the breaker controlling the connection between the permanent generator and the automatic transfer switch (ATS) in the "ON" position, neither of the other (2) breakers can be turned to the "ON" position.
        b. With the breaker controlling the connection between the permanent generator and the automatic transfer switch (ATS) in the "OFF" position, the other (2) breakers can be turned "ON" or "OFF", independent of each other.
        c. With the breaker controlling the connection between the permanent generator and the automatic transfer switch (ATS) in the "OFF" position and with either or both of the other (2) breakers in the "ON" position, the breaker controlling the connection between the permanent generator and the automatic transfer switch (ATS) cannot be turned "ON".
    7. Confirm operation of the 3-way manual transfer switch ground receptacle by attaching a plug to the 3-way manual transfer switch ground receptacle and then verify that the plug is grounded to the facility ground.
    8. Once normal power has been applied, confirm operation of 3-way manual transfer switch by following directions on main access door.

END OF SECTION 26 36 01

SECTION 265100 - LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Lighting fixtures, lamps, and ballasts.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.

B. Related Sections:
1. Division 26 Section "Lighting Control Devices" for occupancy sensors, contactors, and emergency lighting transfer devices.

1.3 DEFINITIONS

A. CRI: Color-rendering index.

B. HID: High-intensity discharge.

1.4 SUBMITTALS

A. Product Data:

1. Light Fixtures: For each type of lighting fixture in schedule, arranged in order of fixture designation. Provide manufacturer’s published literature which includes data on features, accessories, and the following:
a. Dimensions of fixtures.
b. Manufacturer and type of ballasts.
c. Manufacturer and types of lamps.
d. For fixtures (non-exit) with LED light source submit the manufacturer’s IESNA LM-79 Photometric Report and IESNA LM-80 Lumen Maintenance Report.
e. Method of emergency ballast installation (integral, external, or remote).

B. Shop Drawings:
1. Site Lighting Illumination Plan: Provide computer generated isofootcandle plot diagrams for both initial and maintained footcandles on all horizontal patio, landing, walkway, roadway, and parking surfaces which show composite values of illuminance projected from the arrangement of all building mounted and non-building mounted light fixtures. Use manufacturer’s published maintenance factors in calculating maintained footcandles. Calculation grid shall be 2’ x 2’ on pedestrian surfaces and 5’ x 5’ on vehicular surfaces. Also provide spill light isofootcandle plot diagrams for both horizontal and vertical maintained footcandles along property/LEED boundary and 10’ beyond property/LEED boundary. Calculation grid shall be 10’ on center along boundary. Plans depicting building mounted lighting and egress pedestrian surfaces shall be scaled no greater than 1”=10’. Plans depicting vehicular surfaces and property boundary shall be scaled no greater than 1”=30’.

C. Warranty Information: Include in submittals warranty information for emergency exit signs, emergency lighting units, and emergency ballasts installed in schedule fixtures.

D. Coordination Drawings: Reflected ceiling plans and sections drawn to scale and coordinating fixture installation with ceiling grid, ceiling-mounted items, and other components in the vicinity. Include work of all trades that is to be installed near lighting equipment.

E. Test Reports: Report of operation test for emergency lighting units, emergency ballasts, and battery-powered exit signs. See Field Quality Control paragraph below. Submit copy to State Construction Office.

F. Maintenance Data: For lighting fixtures to include in maintenance manuals specified in Division 1. Provide revised and updated Fixture Schedule Matrix. Include all warranty information and documentation with maintenance data.

1.5 QUALITY ASSURANCE

A. Fixtures, Emergency Lighting Units, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.

B. Comply with NFPA 70.

C. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.

1.6 COORDINATION

A. Fixtures, Mounting Hardware, and Trim: Coordinate layout and installation of lighting fixtures with ceiling system and other construction.

B. Coordinate features of devices specified in this Section with systems and components specified in other Sections to form an integrated system of compatible components. Match components and interconnections for optimum performance of specified functions. Include coordination with the following:
1. Division 26 Section "Lighting Control Devices."

1.7 WARRANTY

A. Special Warranty for Electronic Ballasts: Written warranty, executed by manufacturer agreeing to replace fluorescent electronic ballasts that fails in materials or workmanship within 5 years from date of manufacturer, but not less than 4 years from date of Final Acceptance.

B. Special Warranty for Emergency Exit Signs, Emergency Lighting Units, and Emergency Ballasts: Written warranty, executed by manufacturer agreeing to replace entire sign/unit/ballast that fails within 3 years from date of Final Acceptance. The batteries within sign/unit/ballast shall be covered for an additional 2 years by a pro-rated warranty.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Drives: 1 for every 100 of each type and rating installed. Furnish at least two of each type. Includes emergency battery drivers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers and Products: Subject to compliance with requirements, manufacturers and respective products that may be incorporated into the Work are indicated on the drawings in Light Fixture Schedule.
   1. It is the intent of the Light Fixture Schedule to denote the Basis of Design and the specific brand, make, manufacturer and specific name of product desired. Substitution of equivalent products will not be accepted except where specified fixtures or options are no longer available.
      a. Where “or Approved Equal” is listed on Schedule substitution of equivalent products will be acceptable according to the following paragraph.

B. Substitution of Equivalent Products: Substitution of manufacturers and products equivalent to those listed in Light Fixture Schedule shall be submitted to the Engineer for approval. Submittal shall include all items listed in Article 1.4A and an IES photometric report file specific to the fixture configuration being submitted. Photometric calculations for job specific applications shall be provided to Engineer upon request. Engineer has final authority on equivalence and acceptance.

C. Equivalent fixtures, poles, ballasts, and other materials and equipment shall be products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall be a standard product offering as shown on manufacturer’s published printed literature for appearance, mounting, light distribution and lamping (ballast and lens options are excluded from this requirement). Cut-sheets prepared for submittal are not considered published printed literature. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers’ catalogs, or brochures during the 2-year period. Where two or more items of the same type or class of fixture are required, these items shall be products of a single manufacturer.

2.2 FIXTURES AND FIXTURE COMPONENTS, GENERAL

A. Metal Parts: Free from burrs, sharp corners, and edges.

B. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.

D. Reflecting Surfaces: Minimum reflectance as follows, unless otherwise indicated:
   1. White Surfaces: 85 percent.
   2. Specular Surfaces: 83 percent.
   3. Diffusing Specular Surfaces: 75 percent.
   4. Laminated Silver Metallized Film: 90 percent.

E. Lenses, Diffusers, Covers, and Globes: 100 percent virgin acrylic plastic or annealed crystal glass, unless otherwise indicated.
   1. Plastic: High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.
   2. Lens Thickness: 0.125 inch (3 mm) minimum, unless greater thickness is indicated.

F. Wiring:
1. Temperature Rating – Internal to Fixture
a. All wiring shall be code-approved for fixture wiring, and shall comply with the following temperature ratings unless fixture design or local codes require higher temperature wire.
2. Splices
a. Splices internal to fixture shall be made within separate splice compartments and shall utilize nylon insulated crimped connections or insulated quick disconnects.
b. Splices to branch circuit wiring in separate junction boxes shall utilize flame retardant thermoplastic caps with fully seated helical metal spring and threaded entry.
3. No internal wiring shall be visible at normal viewing angles, i.e., above 45° from vertical. Use additional wire clamps if necessary. Anticipate increased visibility if fixtures are mounted on or recessed within a sloping surface.
4. Any fixture fed from more than one panel, i.e., for normal and night or emergency operation, shall have separate neutrals to each panel.
5. Furnish code-approved wiring in ceiling cavities forming air plenums.

2.3 SOLID STATE LIGHTING – LED LUMINAIRES, DRIVERS, AND COMPONENTS

A. General:
1.
2. Luminaire manufacturer shall have a minimum of five (5) years experience in the manufacture and design of LED products and systems and no less than one hundred (100) installations.
3. All LED luminaires and power/data supplies shall be provided by a single manufacturer to ensure compatibility.
4. All components, peripheral devices and control software are to be provided by and shall be the responsibility of a single entity. All components shall perform successfully as a complete system and shall operate as described in Section 265100, Appendix A Lighting Fixture Descriptions/Schedule.
5. Include all components necessary for a complete installation. Provide all power supplies, synchronizers, data cables, and data terminators for a complete working system.
6. Compatibility of driver and LED light engine must be tested and ensured by driver manufacturer.
7. All LED sources used in the LED luminaire shall be of proven quality from established and reputable LED manufacturers and shall have been fabricated after 2007. Acceptable LED lamp manufacturers unless otherwise noted are:
a. Cree, Inc.
b. Philips Lighting
c. Nichia Corporation
d. Norlux
e. Opto Technology, Inc.
f. Osram Optronic Semiconductors

B. Replacement and Spares:
1.
2. Manufacturer shall provide written guarantee of the following:
a. Manufacturer will keep record of original bin for each LED module and have replacement modules from the same bin available for three (3) years after date of installation.
b. Manufacturer will keep an inventory of replacement parts (source assembly, power and control components).
c. Manufacturer's LED system will not become obsolete for ten (10) years: Manufacturer will provide exact replacement parts, or provide upgraded parts that are designed to fit into the original luminaire and provide equivalent distribution and lumen output to the original, without any negative consequences.
3. All parts of system shall be replaceable in field. Manufacturer shall provide written guarantee of the following:

a. Manufacturer has in place a written recycling and re-use program, and will accept returned product and/or components for recycling or re-use.
b. Manufacturer will properly dispose of non-recyclable components that are deemed harmful to the environment.
c. System shall carry a full warranty for five (5) years. Manufacturer shall be responsible for cost of labor not to exceed $50 per individual part, and cost of shipping, to replace any component of the system that fails within 2 years of installation.

4. Products and Components – Performance
a. LED luminaires and components shall be UL listed or UL classified.
b. LED luminaires and components shall be CE certified.
c. LED luminaires and components shall be PSE marked.
d. All LED luminaires shall be subjected to the following JEDEC Reliability Tests for Lead-free Semiconductors: HTOL, RTOL, LTOL, PTMCL, TMSK, Mechanical Shock, Variable Vibration Frequency, SHR, and Autoclave.
e. To ensure luminaire quality, luminaire shall have been tested under accelerated life test conditions including an operating temperature span of 360 degrees F, and cyclic loading up to 60G.
f. All products included in system shall use Mil-Std 810F, Random Vibration 7.698g as a minimum standard. In installations subject to vibration, luminaire shall be installed with vibration isolation hardware to sufficiently dampen vibrations.
g. All LED components shall be mercury and lead-free.
h. All manufacturing processes and materials shall conform to the requirements of the European Union's Restriction on the Use of Hazardous Substances in Electrical and Electronics Equipment (RoHS) Directive, 2002/95/EC.
i. LEDs shall comply with ANSI/NEMA/ANSLG C78.377-2008 – Specifications for the Chromaticity of Solid State Lighting Products. Color shall remain stable throughout the life of the lamp. Color shall match approved sample.
j. LEDs shall comply with IESNA LM-80 – Standards for Lumen Maintenance of LED Lighting Products.
k. White LEDs shall have a rated source life of 50,000 hours under normal operating conditions. RGB LEDs shall have a rated source life of 100,000 hours. LED “rated source life” is defined as the time when a minimum of 70% of initial lumen output remains.
l. Luminaire assembly shall include a method of dissipating heat so as to not degrade life of source, electronic equipment, or lenses. LED luminaire housing shall be designed to transfer heat from the LED board to the outside environment. Luminaire housing shall have no negative impact on life of components.
m. Manufacturer shall supply in writing a range of permissible operating temperatures in which system will perform optimally.
n. High power LED luminaires shall be thermally protected using one or more of the following thermal management techniques: metal core board, gap pad, and/or internal monitoring firmware.
o. LEDs shall be adequately protected from moisture or dust in interior applications.
p. For wet and damp use, LED-based luminaires itself shall be sealed, rated, and tested for appropriate environmental conditions, not accomplished by using an additional housing or enclosure. Such protection shall have no negative impact on rated life of source or components, or if so, such reductions shall be explicitly brought to the attention of the designer.
q. All hardwired connections to LED luminaires shall be reverse polarity protected and provide high voltage protection in the event connections are reversed or shorted during the installation process.
r. The LED luminaire shall be operated at constant and carefully regulated current levels. LEDs shall not be overdriven beyond their specified nominal voltage and current.
s. Manufacturer shall be able to provide supporting documentation of the product meeting third party regulatory compliance.

t. Manufacturer shall ensure that products undergo and successfully meet appropriate design and manufacturability testing including Design FMEA, Process FMEA, Environmental Engineering Considerations and Laboratory Tests, IEC standards and UL/CE testing.
u. All LED luminaires (100% of each lot) shall undergo a minimum twenty-four (24) hour burn-in during manufacturing, prior to shipping.
v. Manufacturer shall provide Luminaire Efficacy (lm/W), total luminous flux (lumens), luminous intensity (candelas) chromaticity coordinates, CCT and CRI. optical performance, polar diagrams, and relevant luminance and illuminance photometric data. Provide data in IES file format in accordance with IES LM-79-2008, based on test results from an independent Nationally Recognized Testing Laboratory.
w. Power / data supply shall have the following:
1) Supply outputs shall have current limiting protection.
2) Supply shall provide miswiring protection.
3) Supply shall have power factor correction.
4) Supply shall provide connections that are conduit-ready or clamp-style connections in the case of low-voltage wiring.
5) Supply shall come with a housing that meets a minimum IP20 rating for dry location installation unless located in a damp or wet location.
6) Supply shall be UL listed for Class 1 or Class 2 wiring

5. LED Control and Communication – Performance
a. LED luminaires shall be network controllable via digital control.
b. The LED system shall use integral and differential non-linear control.
c. Constant data transmission rates shall be employed, resulting in the output being independent of distance of cable between power supply and light source within the specified length.
d. LED system shall have a selectable means of external control via a data network.
e. Each LED luminaire and/or node shall have the capability to be set to a unique and individual address. Address shall be selectable through on board switches or by an external hardware or software method.
f. The LED system shall be scalable, with every LED luminaire/address in the system capable of being controlled by a single, centralized controller.

C. Driver:
1.
2. Ten-year operational life while operating with a case temperature range of 0 degrees C to 62 degrees C and 90 percent non-condensing relative humidity.
3. Electrolytic capacitors to operate at least 20 degrees C below the capacitor's maximum temperature rating when the driver is under fully-loaded conditions and case temperature is 62 degrees C.
4. Designed and tested to withstand electrostatic discharges up to 15,000 V without impairment per IEC 801-2.
5. Maximum inrush current of 2 amperes for 120V and 277 V drivers.
6. Withstand up to a 4,000 volt surge without impairment of performance as defined by ANSI C62.41 Category A.
7. Manufactured in a facility that employ ESD reduction practices in compliance with ANSI/ESD S20.20.
8. Inaudible in a 27 dBA ambient environment.
9. No visible change in light output with a variation of +/- 10 percent line voltage input.
10. Total Harmonic Distortion less than 10 percent and meet ANSI C82.11 maximum allowable THD requirements.

2.4 EMERGENCY EXIT SIGNS

A. General Requirements: Comply with UL 924 and the following:
1. Sign Colors and Lettering Size: Comply with authorities having jurisdiction.

2. Lamps for AC Operation: Light-emitting diodes, 70,000 hours minimum rated lamp life. Maximum LED failure rate shall be 25% within a 7 year period.
3. Emergency Operation: When normal voltage drops below 80% nominal, sign shall switch to operation from emergency battery.
4. Testing Features: Exit sign shall be provided with a test switch to simulate the operation of the unit upon loss of normal power. Sign shall also be provided with pilot light indicating connection of normal power and a pilot indicating high rate charging status.
5. Exit Signs shall be third party listed as emergency lighting equipment, and meet or exceed the following standards: NEC, NC Building Code, NC Energy Conservation Code, NFPA 101, and any applicable NEMA standards.

B. Integral Emergency Battery: Battery shall be sealed, maintenance-free, and sized for a minimum of 90 minutes operating endurance. It shall also be a high temperature type with a re-sealable pressure vent. Battery type and operating range shall be as indicated on lighting schedule. Exterior signs shall be rated to a minimum temperature operating range of -18°C/0°F. Battery shall have normal life expectancy of 10 years. See Warranty requirements Part 1.

C. Battery Charger: Battery charger shall be fully automatic solid state type, full wave rectifying, with current limiting. Charger shall restore the battery to its full charge within 24 hours after a discharge of 90 minutes under full rated load.

2.5 EMERGENCY LIGHTING UNIT

A. General Requirements: Comply with UL 924 and the following:
1. Description: Emergency lighting unit shall be a completely self-contained lighting unit designed to provide emergency illumination upon loss of normal power. Unit contains battery, automatic charger, transfer device, lamps, and testing features.
2. Emergency Operation: When normal voltage drops below 80% nominal, unit shall activate to operate lamps from emergency battery. Lamps are off during normal operation.
3. Testing Features: Units shall be provided with a test switch to simulate the operation of the unit upon loss of normal power. It shall also be provided with pilot light indicating connection of normal power and a pilot indicating high rate charging status.
4. Emergency Lighting Units shall be third party listed as emergency lighting equipment.

B. Emergency Battery: Battery shall be 12V sealed, maintenance-free nickel-cadmium sized for a minimum of 90 minutes operating endurance. It shall also be a high temperature type with an operating range of 0°C to 60°C and contain a resealable pressure vent. Exterior units shall be rated to a minimum temperature operating range of -18°C/0°F. Battery shall have normal life expectancy of 10 years. See Warranty requirements Part 1.

C. Battery Charger: Battery charger shall be fully automatic solid state type, full wave rectifying, with current limiting. Charger shall restore the battery to its full charge within 24 hours after a discharge of 90 minutes under full rated load.

2.6 FIXTURE SUPPORT COMPONENTS

A. Comply with Division 26 Section “Supporting Devices”, for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Refer to “Light Fixture Mounting Detail” on plans for individual fixture support.

2.7 FINISHES

A. Fixtures: Manufacturers’ standard, unless otherwise indicated.
1. Paint Finish: Applied over corrosion-resistant treatment or primer, free of defects.

PART 3 - EXECUTION

3.1 SHIPPING AND STORAGE

A. All fixtures received at the site shall be stored in clean and dry space until fixtures are installed. Fixtures that have become overly dirty shall be replaced at no cost to the owner.

3.2 LOCATION

A. Locations of fixtures are shown diagrammatically. Verify exact location and spacing with Reflected Ceiling Plans and other reference data before ordering of fixtures and during installation.

B. Notify Architect about field conditions at variance with Contract Documents before commencing installation.

C. Coordinate space conditions with other trades before ordering of fixtures.

D. Pendant mount, as approved, surface type fixtures where required to meet space conditions.

3.3 INSTALLATION

A. Provide accessories as required for ceiling construction type indicated on Finish Schedule. Fixture catalog numbers do not necessarily denote specific mounting accessories for type of ceiling in which a fixture may be installed.

B. Fixtures: Set level, plumb, and square with ceiling and walls, and secure according to manufacturer's written instructions and approved submittal materials. Install lamps in each fixture.

C. Install rows of fixtures accurately on straight lines unless otherwise noted on drawings. Coordinate with mechanical work.

D. Support for Fixtures in or on Grid-Type Suspended Ceilings: Use grid for support.
   1. Fixtures within Ceiling Grid: Where a recessed fluorescent, high intensity, or downlight fixture replaces a section or part of a ceiling tile, the fixture shall be supported at the two (2) opposite ends to the building steel/concrete frame or floor decking. Supports shall be provided with the same type of wire as used to support the lay-in ceiling track. Attach one end of the wire to one corner of the luminaire and the other end to the main runners of the lay-in ceiling track at all four (4) corners using sheet metal screws. For fire rated suspended ceiling, luminaire shall be supported to the Building Structure as per the Ceiling Design Criteria, luminaire shall then be screwed to the man runners of the suspended ceiling track at all four (4) corners using sheet metal screws.
   2. Fixtures of Sizes Less Than Ceiling Grid: Arrange as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning between ceiling tees in addition to wires from building structure per above. Channel support shall be attached to ceiling grid using sheet metal screws.
   3. Contractor shall be responsible for verifying weight and mounting method of all fixtures and providing suitable supports. Fixture mounting assemblies shall comply with all local seismic codes and regulations.

E. Contractor shall be responsible for adjusting aperture rings on all ceiling recessed fixtures to accommodate various ceiling material thickness. Contractor shall responsible for coordinating the cut-out size in ceiling to ensure aperture covers cut-out entirely. The bottom of aperture rings shall be flush

with finished ceiling or not more than 1/16" above. Under no circumstances will the aperture ring extend below the finished ceiling surface.

F. Surface Mounted Fixtures: Support surface mounted fixtures from structural members other than ceiling tees.

G. Pendant Mounted Fixtures:
1. Pendant mounted fixtures shall be supported from structural framework of ceiling or from inserts cast into slab.
2. All pendants shall have swivel aligners located at the top ends; pendants shall be 1/2" rigid steel conduit unless specifically indicated otherwise on drawings or in specifications.
3. All fluorescent pendant and surface mounted fixtures shall be supported with two (2) supports per four foot section or three (3) per eight foot section.

H. Bracket Mounted Fixtures: For each bracket fixture, provide flanged metal stem attached to outlet box, with threaded end suitable for supporting the fixture rigidly in design position. Flanged part of fixture stud shall be of broad base type, secured to outlet box at not fewer than three (3) points.

I. Top Relamping Fixtures: Top relamping fixtures shall have the necessary top-relamping screws loosened and moderately tightened, prior to installation, to assure ease of operation when relamping is required.

J. Mask the trims and bottoms of all lighting fixtures if necessary to protect the fixture during construction.

K. At the completion of construction clean the bottoms, the trim, the reflecting surfaces, lenses, baffles, louvers and reflector cones of all lighting fixtures so as to render them free of any material, substance or film foreign to the fixture. If the luminaires are deemed dirty by the Architect at the completion of the project, the Contractor shall clean them at no additional cost to the Owner. Luminaire components whose finishes are damaged shall be replaced at no cost to the Owner.

L. Provide labor and materials for final aiming of all adjustable fixtures under the Architect's supervision. Aiming shall take place immediately before building is turned over to Owner, after regular working hours where required.

3.4 CONNECTIONS

A. Ground equipment.
1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Provide instruments to make and record test results.

C. Tests: As follows:
1. Verify normal operation of each fixture after installation.
2. Emergency Lighting: Interrupt electrical supply to demonstrate proper operation.
a. Contractor shall perform a test on each battery unit after it is permanently installed and charged for a minimum of 24 hours. Battery units shall be tested for 90 minutes and shall maintain not less than 60% of the initial emergency illumination or 87-1/2% of initial battery voltage for the duration of the test. Any unit which fails the test must be repaired or

replaced, and tested again. Copy of testing report for each unit shall be sent to the Engineer.

b. All battery tests shall be complete a minimum of 10 days prior to final inspection.

3. Verify operation of photoelectric controller and contactor.
4. Verify normal transfer to battery source and retransfer to normal.
5. Report results in writing.

D. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

E. Corrosive Fixtures: Replace during warranty period.

3.6 CLEANING AND ADJUSTING

A. Clean fixtures internally and externally after installation. Use methods and materials recommended by manufacturer.

B. Adjust aimable fixtures to provide required light intensities.

END OF SECTION 265100

SECTION 26 72 33 - PERFORMANCE SOUND SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes equipment for amplifying, distributing, and reproducing sound signals for the cafeteria seating area. The Sound Systems shall provide full range audio reproduction and coverage of entire room. The sound system shall consist of wired microphones, auxiliary inputs, mixer/pre-amplifiers, power amplifiers, speakers, wiring, and accessories. The systems shall also have inputs and controls for owner provided music sources. Provide all labor, equipment, supplies, materials, and incidentals associated equipment as necessary to provide fully operational and complete systems.

1.3 SUBMITTALS

A. Product Data: For each type of equipment.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, and location of each field connection.

1. Rack arrangements.
2. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring. Identify terminals to facilitate installation, operation, and maintenance. Include a single-line diagram showing cabling interconnection of components.

C. Product Certificates: Signed by manufacturers of equipment certifying that products furnished comply with specified requirements.

D. Installer Certificates: Signed by manufacturer certifying that installers comply with requirements.

E. Maintenance Data: For equipment to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is an authorized representative of equipment manufacturer for both installation and maintenance of equipment required for this Section.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.

C. Comply with NFPA 70.

D. Comply with UL 50.

1.5 OCCUPANCY ADJUSTMENTS

A. On-Site Assistance: Service representative shall provide on-site assistance in adjusting sound levels, speaker direction, and adjusting controls to meet occupancy conditions. Provide up two on-site assistance visits within six months of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Speaker Manufacturers: Basis of design is the Sx-Series and EVID Series of loudspeakers from Electro-Voice, Inc. Subject to compliance with requirements, other manufacturers offering speaker products that may be incorporated into the Work include Peavey Electronics Corp., JBL Professional, and Yamaha.

B. Equipment Manufacturers: Subject to compliance with requirements, provide listed products by one of the following unless otherwise noted:

1. Mixers/Preamplifiers
   a. Peavey Electronics Corp.
   b. Electro-Voice, Inc.
   c. Yamaha

2. Processors
   a. Shure, Inc.
   b. Peavey Electronics Corp.
   c. Yamaha

3. Power Amplifiers
   a. Peavey Electronics Corp.
   b. Electro-Voice, Inc.
   c. Crown Audio, Inc.

4. Wired and Wireless Microphones
   a. Shure, Inc.
   b. Peavey Electronics Corp.
   c. Electro-Voice, Inc.

5. CD Players
   a. Denon
   b. Marantz
   c. Inter-M Americas

6. Speaker Wire
   a. West Penn Wire / CDT.
   b. Belden Inc.
   c. Or approved equal.

2.2 EQUIPMENT

A. Coordinate features to form an integrated system. Match components and interconnections for optimum performance of specified functions.

B. Equipment: Modular type, using solid-state components, fully rated for continuous duty, unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz.

2.3 LOUDSPEAKERS

A. Basis of Design: Electro-Voice EVID 6.2 loudspeaker.

B. Summary: Loudspeakers shall be full range, two-way loudspeaker system mounted in an injection molded plastic enclosure. Color: Black.

C. Loudspeaker:
1. 2-way full range with integral crossover.
2. Frequency Response: 65 Hz to 20 kHz.
3. Dual 6”Kevlar impregnated woofers.
4. 1” titanium diaphragm tweeter.
5. 200W continuous.
6. Sensitivity: 118 dB 1w/1m.
7. Nominal Impedance: 8 ohms.

D. Mounting: Provide all necessary hardware to wall-mount speakers at heights shown on plans.

2.4 MIXER / PREAMPLIFIERS/PROCESSOR

A. Basis of Design: Peavey Digitool LIVE

B. Comply with EIA SE-101-A; either separately mounted or as an integral part of power amplifier.

C. Inputs: Eight balanced mic/line inputs with one stereo AES inputs.

D. Outputs: Eight electronically balanced line outputs.

E. Equalizer: Digital.

F. Additonal Specifications:

1. Frequency Response: 20Hz to 20kHz @ +0/-1 dB.
2. Input Sensitivity: -70 dBu.
3. EIN: -128 dBu.
4. Total Harmonic Distortion plus Noise: <0.1%.
5. Dimensions: 1 U (rack mountable, 1.75” height)

2.5 POWER AMPLIFIERS

A. Basis of Design: Peavey IP series.

B. Comply with EIA SE-101-A.

C. Amplifiers: solid state dual channel amplifiers

1. Type 1: Peavey IPR2-2000 DSP

a. Digital Display
b. Frequency Response: 10Hz to 30kHz.
c. Total Harmonic Distortion plus Noise: 0.15% THD, 2 channels driven @ 1kHz.
d. Signal to Noise Ratio: -105 dB, A weighted @ 4 Ohms.
e. Output Power:
i. 600W per channel at 4 ohms.

ii. 370W per channel at 8 ohms.
iii. 1100W per channel at 2 ohms.
f. Dimensions: 2 RU (rack mountable, 3.5" height)

2.6 WIRELESS MICROPHONE

A. Basis of Design: Shure SLX Series

B. Summary: Provide a wireless microphone system for the Cafeteria. Each system will be composed of a rack mounted two-channel diversity receiver and two handheld microphone/transmitters. Microphones shall be labeled according to area of use. Wireless systems for Cafeteria shall utilize microphones operating on different frequencies.

C. Equipment:

1. Receiver: SLX4

a. Unit shall have diversity circuitry that constantly monitors signals from both receiver sections and combines them to create a single output signal.
b. Noise-sensing squelch control.
c. Mic/line level switch.
d. Dual RF-level meters.
e. Provide remote antenna.

2. Transmitter: SLX2/58

a. Cardioid dynamic microphone.
b. Frequency response: 50 to 15,000 Hz.
c. 3-Segment, LED battery guage.

D. Mounting: Rack mount receivers. Locate remote antenna for Cafeteria high on wall.

2.7 WIRED MICROPHONE

A. Basis of Design: Shure SM58 (Provide two per system)

B. Summary: Professional voice wired microphone.

C. Additional Specifications:

1. Cardioid dynamic microphone.
2. Pneumatic shock-mount system.
3. On/Off switch.
4. Frequency Response: 50 to 15,000 Hz.
5. 100' cord.

2.8 CD PLAYER:

A. Description: Rack mounted CD player with LCD display capable of playing back regular CDs, CD-R/RW discs, and discs written with MP3 or WMA files. Analog mono XLR and stereo RCA outputs.
1. CD, Bluetooth wireless, SD, USB, and AM/FM tuner playback; auxiliary input.

B. Basis of Design: TASCAM CD-400U.

2.9 HEARING IMPARED LISTENING

A. Basis of Design: Telex SoundMate

B. Mounting: Transmitters shall be rack mounted with respective system. Remote antenna shall be mounted high on Cafeteria wall.

C. Equipment:

1. Transmitters: ST-300.
2. Remote Antennae: HGA-1.
3. Receiver: SR-400 w/ single earbud. Provide 23 receivers.
4. Inductive Neck Loop: NL-4S. Provide 6 neck loops.
5. Battery Charger: BC-100. Provide two chargers per system.

2.10 EQUIPMENT CABINET:

A. Wall Cabinet: Wall-mount modular steel units with standard 19” equipment mounting rails.

1. Approximate Module Dimensions: 28 inches high by 22 inches wide by 22 inches deep.
2. Finish: Black Baked-polyester power coat.
3. Unit shall be double hinged with three sections; rear section, center section and door.
   a. Door: Steel frame, with smoked plexiglass window.
4. Provide (1) 7” equipment drawers in bottom of cabinet to contain microphones and cords.
5. Fill remaining space in cabinet with blank panels.
6. See plans for additional requirements

2.11 AUXILIARY COMPONENTS

A. Microphone Outlets: Combination wall mounted XLR three-pole, polarized, locking-type, microphone input and stereo (L/R) phone (RCA style) jack inputs.
1. Basis of Design: Radio Design Labs #RCX-J3.

B. Cable and Conductors: Jacketed, twisted-pair and twisted-multipair, untinned, solid-copper conductors.

1. Speaker Wire: 12 AWG, twisted pair in PVC jacket. West Penn model 277.
2. Microphone Cables: Neoprene jacketed, not less than 2/64 inch (0.8 mm) thick over shield with filled interstices. Shield No. 34 AWG tinned, soft-copper strands formed into a braid or approved equivalent foil. Shielding coverage on conductors is not less than 60 percent.
3. Plenum Cable: Listed and labeled for plenum installation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment to comply with manufacturer's written instructions.

B. Wiring Method: Install wiring in raceway except within cabinet.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess. Use lacing bars in cabinets.

D. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

E. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

F. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

G. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables to identify media in coordination with system wiring diagrams.

H. Wall-Mounting Outlets: Flush mounted.

I. Conductor Sizing: Unless otherwise indicated, size speaker circuit conductors from racks to loudspeaker outlets not smaller than No. 12 AWG and conductors from microphone receptacles to amplifiers not smaller than No. 22 AWG.

J. Weatherproof Equipment: Install units that are mounted outdoors, in damp locations, or where exposed to weather consistent with requirements of weatherproof rating.

3.2 GROUNDING

A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.

3.3 FIELD QUALITY CONTROL

A. Operational Test: Perform tests that include originating program and page material at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and freedom from noise and distortion.

B. Signal-to-Noise Ratio Test: Measure the ratio of signal to noise of complete system at normal gain settings, using the following procedure:

1. Disconnect a microphone at the connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure the ratio of signal to noise.
2. Minimum acceptance ratio is 50 dB.

C. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure the distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.

D. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use a sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the

levels between locations in the same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.

E. Retesting: Correct deficiencies, revising tap settings of speaker-line matching transformers where necessary to optimize volume and uniformity of sound levels, and retest. Prepare written record tests.

F. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.

G. Schedule tests with at least seven days' advance notice of test performance.

3.4 ADJUSTING

A. On-Site Assistance: Provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions. Provide two visits within 6 months of Substantial Completion.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain equipment as specified below:

1. Train Owners maintenance personnel on programming equipment for starting up and shutting down, troubleshooting, servicing, and maintaining equipment.
2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
3. Schedule training with Owner, through Engineer, with at least seven days' advance notice.

END OF SECTION 26 72 33

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catSECTION 26 75 01 - TELECOMMUNICATION DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The Contractor shall provide the required protection in accordance with the requirements of these specifications and Article 800 of the NEC. The protection shall be provided on both ends of all inter-building cables where required by code or otherwise indicated in the contract documents (i.e. - building-to-building, building-to-modular classroom or building-to-modular complex).

1.2 SUMMARY

A. This Section includes a Telecommunication Distribution System which is ready for the installation of active electronic equipment such as routers, bridges, switches, repeaters, adapters, etc. The system shall incorporate all requirements of this specification.

1.3 PRELIMINARY MEETING

A. Technical Support Staff and Experience

1. The Contractor shall provide a list of its project management staff and technical support staff to be assigned to this project together with their resumes and working experience.
2. The Contractor shall utilize certified cable installers and technicians with approved vendor specific certification. The Contractor shall supply certification documentation for cable installers.
3. The Contractor shall state their nearest branch office and dealer's office in relation to the proposed site of the cabling system. If none, the location of the main office shall be stated.
4. The Contractor shall state their nearest location of their principal support center. This center shall have permanently stationed support staff that is capable of providing technical support if required.

B. An initial planning meeting will be held with the Contractor to clarify all requirements (systems, services, distribution methods, etc.), identify responsibilities, and schedule the events that will transpire during the implementation of the project. This meeting should be held no later than thirty (30) days after NTP has been issued.

C. Within ninety (90) days of the completion of the facilities planning meeting, the Contractor shall prepare and provide two (2) copies of the following documentation for review and approval by the Architect:

1. Shop Drawing:
   a) MDF and IDF Diagrams - Includes cable routing, position of all components and apparatus, detailed layout of the wall field, and labeled cable plant drawing.
   b) Work Area Floor Plans - Includes detailed cable routes and labeling plan for all work areas. The Contractor shall obtain floor plans from the Architect in AutoCAD format, if so desired, to aid in preparing the submittal.
   c) Cross Connect Documentation - Provide cross connect records for all voice and data devices.
   d) Backbone Distribution Plan
2. Schedule of work: See Construction Schedules and Reports Section 01311 and Attachment 16741-1G.

1.4 CONTRACTOR CLOSE OUT DOCUMENTS

A. Upon completion of the project, Contractor shall prepare "As Built" documentation showing actual site conditions and installation as constructed, and provide copies of such documentation as per paragraph 1.3C.

B. In addition to the engineering diagrams, the following items shall be provided by the Contractor at substantial completion:

1. Laminated cable schedules, sized 8 ½" x 11", to be hung in the appropriate rooms in an approved manner (see Attachments 16741-1A through 16741-1F).
2. Record of field tests of System.

e) The data TCO identification numbers and fiber identification numbers used in recording test results shall be the same as those shown on the 'As-Built' plans and cable schedules.

3. Building Control Plans in the following format:

a. Four (4) copies (for owner) and one reproducible sepia of all diagrams and drawings, "D" size (24" x 36") or "E" size (30" x 42") as appropriate.
b. Two (2) copies of all cross connect documentation in printed form.

4. One size "E" laminated drawings of "As-Builts" and one "E" size laminated drawing of riser diagrams and outlet schedules shall be attached to the wall with approved fasteners in the MDF. Color key data cabling blue, CCTV green, and fiber optic data cabling orange. Highlight, in some manner, the MDF/IDF/FDE rooms.

C. The Contractor shall furnish a chart indicating cable termination locations from end to end. This document shall be page-numbered, laminated and attached to each distribution frame along with a copy submitted with As-Builts (not laminated) in a three-ring binder (see Attachment 16741-1A through 16741-1F).

D. The Contractor shall furnish to the Owner all closeout documentation in a three-ring binder with proper labeling on cover and the end of the binder.

E. System Warranty

1. The Contractor shall provide a five- (5) year warranty for both products and labor and a fifteen (15) year manufacturer's warranty on all parts installed.
2. Service must be provided within twenty-four (24) hours of notification for emergency situations and within seventy-two (72) hours for routine service.

1.5 PRODUCT SUBMITTALS

A. General: Submit the following according to Conditions of the Contract and Division 1 Specification Sections.

1. Product data for system components
2. Shop Drawing as defined

1.6 QUALITY ASSURANCE

A. Comply as applicable with ANSI/TIA/EIA-568-B.1, ANSI/TIA/EIA-568-B.2 and ANSI/TIA/EIA-568-B.3 "Commercial Building Telecommunications Cabling Standard." February 2003 or current release available.

B. Comply as applicable with ANSI/TIA/EIA-569-A, "Commercial Building Standard for Telecommunications Pathways and Spaces." February 1998, or current release available

C. Comply as applicable with ANSI/TIA/EIA-606, "The Administration Standard for Telecommunications Infrastructure of Commercial Buildings." May 2002, or current release available

D. Comply as applicable with J-STD-607, "Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications." October 2002, or current release available

E. Comply with NFPA 70, "National Electrical Code." 2011

F. "Nationally Recognized Testing Laboratory" (NRTL) Listing: Provide materials that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.
2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
3. FCC Regulations: Comply with FCC Part 68, Chapter 1, "US Code of Federal Regulations," Title 47 for all telephone system wire and cable connection components.

PART 2 – PRODUCTS

2.1 HORIZONTAL CABLE

Contractor shall provide all horizontal cables.

A. CATEGORY CABLE (Cat6~~A~~)
1. Subject to compliance with requirements, provide products as manufactured by one of the following:
   a. BerkTek - Leviton
2. All cables shall conform to or exceed the TIA/EIA 568-B.2 Category 6 “Commercial Building Telecommunications Cabling Standard” – Part 2: Balanced Twisted Pair Cabling Components.
3. Other standards supported include IEEE 802.3.1, 1000 BASE-T, 100 BASETX and ANSI X3T9.5 TP-PMD requirements for UTP at 250 MHz.
4. All cables shall be composed of 4-pair 24 AWG solid copper conductors.
5. The cable shall meet the NEC requirements for CMP type (Plenum Rated).
6. Jacket Color: Data cables shall be distinguished by jacket color. Colors shall be as follows.
   a. Data cables: White
   b. Wireless Access Points (WAPs): Blue
   c. CCTV Cameras, Video Entry System: Yellow
   d. Intercom (IP Type): Orange
   e. BAS: Blue
   f. Fire: Red

B. FIBER OPTIC CABLE

1. All cables shall conform to or exceed the TIA/EIA-568-B.3 Commercial Building Telecommunications Cabling Standard – Part 3: Optical Fiber Cabling Component Standard.
2. The multi-core optical fiber shall consist of multimode 50/125µ fibers, bandwidth 2000MHz • km, and comply with ANSI/TIA/EIA-492AAA as specified in TIA/EIA 568-B.3.
3. Each fiber shall be tight-buffered with color-coded PVC.
4. The fiber cable shall meet the NEC requirements for OFNP and comply with Bellcore, FDDI, TIA/EIA 568-B.3 and ICEA standards.

5. Connectors shall be crimp-on type, prepolished SC connectors with a maximum loss of 3.0 dB.

2.2 TELECOMMUNICATIONS OUTLET (TCO)

A. CATEGORY COPPER (Cat6~~A~~)

1. Shall be modular, RJ45 type/8-position/8 conductor.
2. Keystone Jacks shall be same color as cabling connected to them. See CATEGORY CABLE (Cat6~~A~~) requirements above.
3. Shall be universal application/multi-vendor supportive accepting most phone and data plugs.
4. Modular connectors shall be flush with outlet faceplate.
5. Cover shall match those indicated for power receptacle outlets in same spaces for materials and finish.
6. Covers shall have plastic windows for data labeling.
7. Outlets shall be wired in a TIA/EIA 568B configuration. TIA/EIA Category 6 (Cat 6A)

2.3 PATCH PANEL

A. CATEGORY COPPER (Cat6~~A~~)

1. The panel shall support the Cat6~~A~~ applications and facilitate cross-connection and inter-connection using patch cords.
2. The wiring blocks shall be fire-retardant, molded plastic consisting of horizontal index strips for terminating conductors. These index strips shall be marked with four colors on the high teeth, separating the tip and ring of each pair, to establish pair location.
3. The panel shall be able to accommodate over 500 repeated insertions without incurring permanent deformation and it shall pass the reliability test of no more than one contact failure in 10,000 connections.
4. Nineteen (19") rack mountable patch panels shall be used. Patch panel installations shall contain a retaining trough between every 100 pair termination block.
5. The panel shall be able to accommodate 24 AWG cable conductors.
6. The panel shall be Underwriter's Laboratories Inc. (UL) listed.
7. Shall be wired in a TIA/EIA 568B configuration.
8. The color of the jacks shall match the cabling jacket color (see above)
9. Dedicated patch panels shall be provided for each jack/jacket color.

2.4 FIBER OPTIC DISTRIBUTION ENCLOSURE (FDE) / FIBER OPTIC TERMINATION ENCLOSURE (FTE) / FIBER OPTIC TERMINATION SHELF(RACK MOUNT)

A. Shall provide cross-connect, inter-connect, splicing capabilities, and contain the proper troughs for supporting and routing the fiber cables/jumpers.

B. Shall consist of a modular enclosure with retainer rings in the slack storage section to limit the bend radius of fibers.

C. Shall have a "window" section to insert fiber optic adapter panels for mounting of SC adapters.

D. Connectors shall meet or exceed the following specifications:

1. Operating Temperature: -40 °to 185°F (-40° to 85°C)
2. Maximum Loss: 3.0 dB

E. Shall provide terminating capability of 6, 12, 24, 48, or 72 connectors as indicated on plans or as required for number of fibers.

F. All enclosure housing shall be metal. All terminations shall be enclosed in housing with access door.

G. FDE's shall contain no patch cables. Contractor shall use SC fiber bulkhead connectors to achieve the pass-through.

H. Pull out fiber trays are not allowed.

2.5 BACKBONE/VOICE DISTRIBUTION CABLE

A. FIBER OPTIC

1. Fiber optic cables shall be Optical Cable Corporation Distribution Cables, Plenum-Rated. Equivalent cables from other vendors will be allowed.
2. The multi-core optical fiber shall consist of multimode 50/125µ fibers, bandwidth 2000MHz • km, and comply with ANSI/TIA/EIA-492AAAA as specified in TIA/EIA 568-B.3Each fiber shall be tight-buffered with color-coded PVC.
3. The fiber cable shall meet the NEC requirements for OFNP and comply with Bellcore, FDDI, TIA/EIA-568-B.2 and ICEA standards.
4. All fiber must be armored.

2.6 MISCELLANEOUS

A. BACKBOARD

1. 3/4-inch (19 mm) interior grade type AC plywood. Paint all sides of plywood with flame retardant paint.

B. TERMINATION LABELS

1. Shall conform to ANSI/TIA/EIA-606. Labels will have pressure sensitive, permanent acrylic type adhesive. P-Touch type weatherproof or equal

C. SURGE/TRANSIENT PROTECTOR PANEL

1. Lucent Technologies 110ANA1-25 Multi-pair Protector Panels or approved equal for each twenty-five (25) pair cable on both ends where the cable enters the building. Use multiple units for higher pair count cables or multiple cables. The protector units to be provided by the Contractor.

D. OPTICAL FIBER RACEWAY

1. Flexible telecommunication raceway (innerduct) designed and listed specifically for use with fiber optic cables. All innerduct installed shall be listed Plenum-rated. General-rated will NOT be allowed. Plenum Rated label must be stamped or printed on product. Only fiber optic cable shall be installed in this raceway. All optical fiber raceway shall have a diameter of 1"- minimum.
2. Color: Optical Fiber Raceway shall be orange.

E. OPTICAL FIBER RACEWAY FITTINGS

1. Fittings shall be specifically designed to match raceway type and material.

F. FLOOR MOUNTED ADJUSTABLE DUAL EQUIPMENT RACK: (Located in MDF Room)
   1. 4-post rack system with dual sided horizontal and vertical wire management designed for proposed 4 post rack. Rack shall be equivalent to Panduit's "NetRunner" cable manager system.
   2. Rack shall be 84"H x 20.19"W x 21.0-32.0"D (Depth is adjustable in ½" increments)
   3. Steel construction -100lbs load rating
   4. Rack Units-45
   5. Provide with one (1) adjustable equipment shelf vented (3.34"H x 17.5"W x 27"-32"D)
   6. Provide with Vertical cable management for the entire length of rack front and rear

PART 3 – EXECUTION

3.1 GENERAL REQUIREMENTS

A. The Contractor shall maintain conductor polarity (tip and ring) identification at the MDF, the Telecommunications subclosets risers, and station connecting blocks in accordance with industry practices.

B. The Contractor shall provide all cables. All communication cable installed by the Contractor shall be fully tested in accordance with TIA/EIA-568-B.2 (for UTP) and TIA/EIA 526-14-A-B.14 prior to acceptance.

C. The Contractor shall test all fiber optic cable prior to the installation of the cable. The Contractor shall assume all liability for the replacement of the cable should it be found defective at a later date. Fiber test must be bi-directional after installation through all FDE's and show footage

D. The Contractor shall provide any necessary screws, anchors, clamps, tie wraps, distribution rings, wiring duct (MDF & IDF locations), miscellaneous grounding and support hardware, etc., necessary to facilitate the installation of the System in a neat and orderly fashion as approved by the Engineer.

E. It shall be the responsibility of the Contractor to furnish any special installation equipment or tools necessary to properly complete the System. This may include, but is not limited to, tools for terminating cables, testing and splicing equipment for copper/fiber cables, communication devices, jack stands for cable reels, or cable winches.

F. The Contractor shall be responsible for printed labels for all cables and cords, distribution frames, and outlet locations, according to the specifications. No labels are to be written by hand including numbers on boots. Approval must be obtained from Weldon Schools for labeling devices used.

G. The Contractor shall not place or attach any telecommunications cabling alongside power lines, or share the same conduit, channel or sleeve with electrical apparatus.

H. The Contractor shall ensure that the maximum pulling tensions of the specified distribution cables are not exceeded and cable bends maintain the proper radius during the placement of the facilities. Failure to follow the appropriate guidelines will require the Contractor to provide in a timely fashion the additional material and labor necessary to properly rectify the situation. This shall also apply to any and all damages sustained to the cables by the Contractor during the implementation.

I. The Contractor shall be responsible for providing an approved ground at all newly installed distribution frames, and insuring proper bonding to any existing facilities. The Contractor shall also be responsible for ensuring ground continuity by properly bonding all appropriate cabling, closures, cabinets, service boxes and framework. All grounds and bonding shall consist of green #6 AWG solid copper wire and shall be supplied from an approved building ground and bonded to the main electrical ground in compliance with J-

STD-607 “Commercial Building Ground (Earthing) and Bonding Requirements for Telecommunications”, Sections 2.1 and 5.3.

J. The Contractor shall furnish a chart indicating cable termination locations from end to end. This document shall be page-numbered, laminated and attached to each distribution frame along with a copy submitted with As-Builts (not laminated) in a three-ring binder (see Attachment 16741-1A through 16741-1F).

K. The Contractor shall furnish to the Owner all closeout documentation in a three-ring binder with proper labeling on cover and the end of the binder.

L. Any data cable that is not located in the same room as the Hub Cabinet, Rebox, or IDF must have a full label on the cable at both ends.

M. The Contractor shall install the necessary biscuit jacks as indicated on drawings. The Contractor shall install a Cat6 cable from the biscuit jack to the appropriate service equipment. That Cat6 cable is to be installed by the vendor for that service equipment. The Owner will install the patch cord to the phone service. The Contractor is to install the Cat6 cable in the biscuit jack only.

3.2 INSTALLATION, GENERAL

A. Telephone Service: Comply with telephone utility organization requirements as to details of the telephone service.

B. Distribution System: Complete installation required. The system will be fully operational when instruments and electronic equipment are connected.

C. Raceway: Install service and distribution raceway for all cabling as indicated.

D. Conduit sleeves for Computer Network Infrastructure shall be installed not more than four inches (4") from wall and shall be stubbed at a maximum of four inches (4") above or below finished floor. Plastic bushings and pull wires shall be provided.

E. Where the protector panels are installed in a room with a plywood backboard, mount directly on backboard. Where the protector panels are installed on the exterior of the building, mount in a NEMA 3R enclosure (Hoffman Screw Cover Type 3R Enclosures - Bulletin A-3 or equal). Where the protector panels are installed indoors in a room without a backboard, mount in a NEMA 1 enclosure (Hoffman Small Type I Enclosures Bulletin A-2). Size as required to accommodate all devices and wiring with adequate clearance. Contractor will provide Protector units.

3.3 HORIZONTAL CABLE INSTALLATION

A. Obtain approval of all raceway system installation from Engineer prior to installing any cable. Install cable without damaging conductors or jacket. Do not bend cable to a smaller radius than minimum recommended by manufacturer. Do not exceed manufacturer's recommended pulling tensions. Pull cables simultaneously where more than one is being installed in the same raceway or at the same location. Use pulling compound or lubricant where necessary. Compound used must not damage conductor or insulation. Use pulling methods that will not damage cable or raceway, including fish tape, cable, rope and wire-cable grips.

B. Wiring Method:

1. Install outlet boxes with jack assemblies at outlets. Install cable in raceway in wall. Terminate raceway with a bushing in ceiling space above outlet except as otherwise indicated. Run cable concealed in accessible ceiling space except as otherwise indicated.
2. Fiber optic cable shall be installed in raceway from MDF to IDF. All fiber optic cable shall be installed in optical fiber raceway (innerduct). Minimum one inch (1") in diameter or other raceway (i.e. conduit). There shall be no exposed conduit or fiber optic cabling. Utilize fitting and boxes specifically designed for use with the associated raceway. Each end of the fiber shall contain a slack storage box with approximately 6 feet (6') of cable slack. Provide pull boxes for innerduct at a maximum of one hundred feet (100').
3. Provide bushings on all conduits stubbed into ceiling void.
4. Copper Cable above finished ceilings: Install parallel or perpendicular to surfaces or exposed structural members and follow surface contours where possible.

    a. Cable Support: Secure cable to independent supports at intervals as required preventing sagging between supports. Use metallic supports with corrosion-resistant finish.
    b. Splices: Do not splice cable between the normal terminations of runs.
    c. No Dropped Ceiling: Route in conduit along structure.
    d. Attach cable to building structure only as per NEC-800.

5. In suspended ceiling and raised floor areas where duct, cable trays or conduit are not available, the Contractor shall bundle horizontal Cat6 wiring with wire ties at appropriate distances. The cable bundling shall be supported via Cat 6 "J" hooks or Cat 6 bridle rings with saddles attached to the existing building structure and framework. Use of Velcro straps is prohibited.

C. The 4-pair UTP cables shall be installed using a star topology format from the administration subsystem on each floor to every individual TCO.

D. The length of any horizontal Cat6 cable shall not exceed 295-ft (90 m).

E. In the event Contractor is required to remove ceiling tiles, such work shall not break or disturb grid and must be coordinated with the Prime Contractor. Any damaged tiles after the ceiling is installed shall be replaced under this contract.

F. Conduit installed by the Contractor should not exceed one hundred feet (100') or contain more than two (2) 90-degree bends without utilizing appropriately sized pull boxes.

G. No Condulets may be used.

H. Cabling in Telecommunications Subclosets and Cabinets: Install conductors parallel to and at right angles to walls. Bundle, lace and train the conductors to terminal points with no excess. Use wire distribution spools at points where cables are fanned or conductors turned. Connect conductors that are terminated, spliced or interrupted to terminal blocks.

I. Conductor Terminations: Terminate conductors of cables on terminal block using tools recommended by terminal block manufacturer.

J. Cabling in Classrooms: Install conductors from each outlet around the perimeter of the room to the nearest IDF closet (where not indicated on plans). All cables in room shall go to the same IDF closet. Do not route cables diagonally across the rooms. Cables are to be supported from walls with j-hooks.

3.4 TELECOMMUNICATION OUTLET (TCO)

A. Unless otherwise noted on the floor plans, the TCO shall be flush mounted.

B. Outlet jacks shall be color keyed to match cabling: See CATEGORY CABLE (Cat6) requirements for additional information.

3.5 FEEDER CABLE

A. Contractor shall obtain approval of all raceway systems installation from the engineer prior to installing any cable.

B. Contractor shall install the feeder cables in a star topology, terminated in the MDF at one end and in the FDE in a Telecommunications subcloset at the other end.

C. All fibers shall be installed in raceway (innerduct) and terminated with prepolished, crimp-on SC-style connectors at termination or distribution enclosures or at termination shelves equipped with sufficient panels, adapters and jumper storage to terminate and secure all fibers.

D. The fiber cable shall be protected by optical fiber raceway or appropriate apparatus at all times. Each end of the fiber cable shall contain a slack storage box with approximately 6 feet (6') feet of cable slack.

3.6 OUTSIDE CABLE

A. All buried cable shall be contained in a raceway system. When using PVC conduit, a metallic locating tape shall be installed twelve inches (12") below grade.

B. Contractor shall obtain approval of all raceway system installation from the Engineer prior to installing any cable.

C. Provide hand holes on all underground inner building (between buildings) conduit runs that change direction.

D. Contractor shall provide electrical lightning/surge protection panels and protector units on copper cables that will prevent electrical surges on the cable from entering buildings.

E. It shall be the responsibility of the Contractor to stake all areas along the cable route forty-eight (48) hours prior to any trenching or digging.

F. The Contractor shall be responsible for restoring any disturbed earth to its original condition. A reasonable effort shall include any landscaping, seeding, or replacement of shrubbery that may be required to properly restore the excavated area. If settling should occur, the installation Contractor shall be responsible for any secondary restoration.

3.7 GROUNDING

A. Communications Systems- In compliance with NEC 2002, Article 800, J-STD-607-A.2.1, J-STD-607-A-5.1, and J-STD-607-Annex B.

1. Install a #6 AWG green insulated solid copper ground wire from the main building service entrance grounding system to the MDF Telecommunications Main Grounding Busbar (TMGB).
2. Install a #6 AWG green insulated solid copper ground wire from the TMGB to each Telecommunications Cabinet in the MDF.
3. DO NOT GROUND OR BOND TO THE BUILDING STRUCTURE (see detail on drawings).

B. Contractor shall install a copper busbar for grounding of communication systems.

3.8 IDENTIFICATION

A. Provide identification in accordance with the recommendations of ANSI/TIA/EIA-606, “Administration Standard for Telecommunications Infrastructure” Refer to labeling descriptions below.

3.9 TELECOMMUNICATIONS LABELING LEGEND

A. Copper Telecommunications Outlet (TCO) – “X-RMNNN-BNN”:

1. Where “X” equals ”MDF” (Main Distribution Frame), “IDF” (Intermediate Distribution Facility), “HC” (Hub Cabinet) or “RB” (Rebox) indicating where the cable is terminated at the other end.
2. Where “NNN” equals the room number where the MDF, IDF, HC or RB is located.
3. Where “B” equals the outlet designation symbolized by “V” for voice, “D” for data, or “F” for fiber.
4. Where “NN” equals the unique outlet/fiber number. This number shall be consecutive for each MDF, IDF, HC or RB and shall be numbered 01, 02, 03 etc.

B. Label all cables in each HC with a corresponding TCO number.

C. Patch Panels – Label each outlet at the MDF, IDF, or RB patch panels with a corresponding outlet number. Numbering shall be from left to right and from top to bottom with consecutive numbers. *Note: All labels shall be uniform in size using the same font size on letters and numbers (block style) through out.

D. Outlet numbers shall match exactly at both ends of all copper voice distribution feeder cables.

E. If the data cables and Hub Cabinet/Rebox are all contained within the same room, the data labels may read D1, D2, D3 etc. If not, they must have a full label at both ends.

F. Fiber Station Cables and Fiber Distribution Enclosures (FDE) – label as follows:

G. Labeling for the backbone distribution fiber cable – At the MDF label all fiber connectors sequentially from left to right, top to bottom. This number should carry all the way to the Hub Cabinet. These numbers shall match at all FDE’s. Tag cable at all connections Format of label is “Fiber Feeder Cable to X–RMNNN NNN-NNN”:

1. Where “X” equals “MDF” or “FDE”.
2. Where “NNN” is the room number where the MDF or FDE is located.
3. Where “NNN-NNN” equals the beginning and ending numbers for that feeder cable.

3.10 FIELD QUALITY CONTROL

A. Test Notice: Provide at least 10 days' notice in writing when the system is ready for final acceptance testing.

B. Acceptance Tests: Include the following for each pair or conductor of each cable run.

1. 100 percent of the horizontal and riser wiring pairs shall be tested for opens, shorts, polarity reversals, transposition and presence of AC voltage.
2. Voice and data horizontal wiring pairs shall be tested from the TCO to the patch panel or block, the basic link test.

C. Data cables shall be tested for conformance to the specifications of TIA/EIA-568-B.2 for Cat6 copper cables.

1. Wire Mapping shall be done to ensure proper wiring and connectivity. Test for:

    a. Continuity, end-to-end.
    b. Shorts between any two or more conductors.
    c. Crossed pairs
    d. Reversed pairs
    e. Split pairs
    f. Other mis-wirings
    g. Document as Pass / Fail

2. Length shall be measured. Indicate the length of the cable as the pair with the shortest length and record it.
3. Attenuation shall be tested with a remote signal injector and a reading made at the local end. Evaluate the worst pair attenuation and record result on test report.
4. Bi-Directional NEXT. Near-end crosstalk (NEXT) shall be tested on all six pair combinations in each four pair cable. Tests for NEXT shall be performed from both the work area outlet location and link origination point.
5. Fiber optic cables shall be tested in accordance with the requirements of TIA/EIA-526-14-A-B.1.4 Annex B (Bi-directional Testing). Maximum dB loss shall be 3.0. Show footage on test reports. Notify Engineer of exceptions by cable ID number and give reasons for the exceptions.
6. Computer generated test results must be submitted to the Engineer. The test results must state the dB loss of the fiber as a single value, not baseline value and test value.

D. Re-testing: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify that the total system meets the Specifications and complies with applicable standards.

E. Report of Tests and Inspections: Prepare a written record of inspections, tests, and detailed test results in the form of a test log and format the log in cable ID number order.

3.11 Entrance Facilities:

A. An entrance raceway (conduit), meeting the following specifications shall be provided by the Contractor for the use of the local telephone service provider.

B. General – (Conduit)

1. Contractor will install a quantity of two (2) 4-inch conduits from the owners' property line, as specified by the local telephone service provider, to the main telecommunications room.
2. Conduits to be intermediate metal, rigid metal, or rigid non-metallic conduit installed in accordance with Articles 345, 346, or 347, respectively, of the National Electric Code.
3. Contractor shall bury conduit to a depth between twenty-four inches (24") and thirty-six inches (36") below final grade.
4. Contractor shall equip conduit with no more than the equivalent of two-quarter bends (a total of 180 degrees) between cable pulling points.
5. All conduit bends shall have a minimum radius of ten (10) times the inside diameter of the conduit. LB's will not be acceptable.
6. Contractor shall equip conduits with a mule tape with footage on tape.

C. Field Side – (Conduit at Right of Way)

1. Contractor shall cap conduit to prevent debris and water from entering before cable placement.

2. Contractor shall run conduits to a hand hole (30” x 48” x 36”) and the hand hole in locations designated by the Owner.

D. Building Side – (At Main Telecommunications Room)

1. The responsibility to seal entrance conduits to protect against water damage is left entirely with the Contractor.
2. All fire rated structures that are penetrated during conduit or cable placement must be fire-stopped by the Contractor.

E. The telephone service provider shall terminate its entrance cables inside the building in the Main Telecommunications Distribution Room. This area will be provided by the Contractor with following requirements met:

1. Contractor shall equip area with an 8’ wide x 4’ high x ¾” thick fire retardant plywood backboard, with visible fire rating, and securely fastened to the wall.
2. Contractor shall equip backboard with a standard duplex convenience outlet.
3. Contractor shall maintain clear path to this area and a 3’ maintenance area directly in front of terminal area.
4. Contractor shall equip area with direct lighting sufficient for a uniform light intensity of 30-foot candles measured at floor level.

F. Grounding and Bonding

1. Refer to 267501-3.7.A (see detail on drawings).

END OF SECTION 26 75 01

SECTION 268311 – FIRE ALARM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SCOPE

A. This section of the specifications includes the furnishing, installation, and connection of the microprocessor controlled, addressable/intelligent reporting voice-evacuation fire alarm equipment required to form a complete coordinated system ready for operation. It shall include, but not be limited to, alarm initiating devices, alarm notification appliances, control panels, auxiliary control devices, annunciators, power supplies, and wiring as shown on the Drawings and specified herein.

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of fire alarm systems of types, sizes, and electrical characteristics required, and whose products are Listed and Labeled. All products, including initiating devices and notification appliances, shall be as produced or supplied by the same manufacturer as the fire alarm control panel. Products of firms that do not maintain factory authorized service organization and spare parts stock are not acceptable for use on this project.

B. Installer Qualifications: An experienced Installer who is an authorized representative of the FACP manufacturer for both installations and maintenance of all equipment required for this Project. The Installer technicians shall be individually certified NICET Level 2 and by the manufacturer of the equipment and trained and certified on the specific model being installed. Installer shall have at least one technician on staff certified NICET Level 3. Certification shall be current to latest release and must have occurred in the most recent 24 months. All connections to the FACP and the systems programming shall be completed only by Installer technicians compliant with qualifications. Copies of certifications shall be submitted with shop drawings.

C. Codes and Standards:

1. NFPA Compliance: Comply with applicable requirements of NFPA-72, National Fire Alarm Code.
2. NEC Compliance: Comply with applicable requirements of NFPA-70, National Electrical Code (NEC) standards pertaining to fire alarm systems.
3. Testing Laboratory Compliance: Comply with provisions of UL safety standards pertaining to fire alarm systems. Provide products and components which are Listed and Labeled.
4. State Building Code Compliance: Comply with applicable requirements of South Carolina State Building Code.
5. Fire Marshall Compliance: Provide fire alarm systems and accessories which are Fire Marshall approved.
6. Comply with Authority Having Jurisdiction.

1.4 SUBMITTALS - GENERAL

A. Submittals shall demonstrate compliance with technical requirements by reference to each subsection of this specification. Where a submitted item does not comply fully with each and every requirement of the

specifications, the submittal shall clearly indicate such deviations. Identification requirements for non-complying features of items are very specific.

1. Installer Certifications: Copies of manufacturer signed certifications and NICET certifications as required above.
2. Product Data: Submit Manufacturer's technical product data, including specifications and installation instructions, for each type of fire alarm system equipment.
3. Battery Sizing Calculations. Also submit voltage drop and current draw calculations for control panel and NAC panels.
4. Shop Drawings: Submit (2) bound full size sets of shop drawings showing equipment, device locations, and connecting wiring of entire fire alarm system depicted on scaled architectural floor plans with Installer's border sheet. Include wiring and riser diagrams and battery calculations. Provide distance and proposed route for each notification appliance circuit. Devices shall include proposed address label. Electronic copy of architectural floor plans will be provided by Engineer in format compatible with most recent release of AutoCAD upon request. Copies of Project Construction Documents or details there from may NOT be a part of the shop drawing submittal.
5. Authority Having Jurisdiction Submittal: Submit (1) one copy of Product Data and Shop Drawings as specified above to Authority Having Jurisdiction. Resubmit if required to make clarifications or revisions to obtain approval.
6. Maintenance Data: Submit maintenance data and parts lists for each type of fire alarm equipment installed, including furnished specialties and accessories. Include this data, product data, and shop drawings in maintenance manual.
7. As-Builts: Submit (1) one electronic copy of full size sets of scaled architectural floor plans depicting final device and equipment locations, all circuiting, and pathway and terminal cabinet locations. Include wiring and riser diagrams with battery calculations based off of installation. Also submit (1) electronic copy of Product Data, Installation Instructions, Device Address List, System Matrix, System Status and Programming Report and all other pertinent information specified elsewhere within document.
8. Test Reports: Submit a letter and a copy of the test report indicating proper functioning of the system, and conformance to the requirements of the Contact Documents.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Due to existing facilities on site, new FACP must be compatible with existing fire lite notification and detection devices.
   1. FireLite by Honeywell

2.2 FIRE ALARM CONTROL PANEL (FACP)

A. General: The FACP shall meet the following general requirements:

   1. The fire alarm panel shall be a voice evacuation system, complete with speakers to meet the audibility requirements as defined in NFPA 72.
   2. Signal Line Circuits: Alarm, trouble and supervisory signals from all intelligent reporting devices shall be encoded onto an NFPA Style 6 (Class A) Signaling Line Circuit (SLC).
   3. Initiation Device Circuits: Initiation Device Circuits (IDC) shall be wired Class A (NFPA Style D).
   4. Notification Appliance Circuits: Notification appliance circuits shall be wired Class B (NFPA Style Y).

5. Digitized electronic signals shall employ check digits or multiple polling. In general a single ground or open on any system signaling line circuit, initiating device circuit, or notification appliance circuit shall not cause system malfunction, loss of operating power or the ability to report an alarm.
6. Loss of Power: Alarm signals arriving at the main FACP shall not be lost following a power failure (or outage) until the alarm signal is processed and recorded.
7. System Response to an Alarm Condition: When a fire alarm condition is detected and reported by one of the systems initiating devices or appliances, the following functions shall immediately occur:
    a. The system alarm LED shall flash. A local piezo-electric signal in the control panel shall sound.
    b. The 80-character LCD display shall indicate all information associated with the fire alarm condition, including the type of alarm point and its location within the protected premises.
    c. On systems equipped with a printer, printing and history storage equipment shall log the information associated each new fire alarm control panel condition, along with time and date of occurrence.
    d. All system output programs assigned via control-by-event equations to be activated by the particular point in alarm shall be executed, and the associated system outputs (alarm notification appliances and/or relays) shall be activated. Exact programming shall be provided by the Contractor to meet the Owners requirements.
    e. Activate all alarm notification appliances in the building, sounding and flashing in synchronization continuously until manually silenced, or until the initiating device and control unit have been reset to normal condition.
    f. Activate digital alarm communicator.
    g. Deactivate door hold control relay such that all smoke doors are allowed to close.
8. System Response to a Trouble Condition:
    a. System AC power trouble signal shall not be sent unless maintained for 8 hours (or more).
    b. Provide adjustable time delay for all trouble signals prior to transmission.
    c. Default setting shall be immediate transmission for all supervising signals.

B. FACP - Minimum Requirements: The FACP shall contain a microprocessor based Central Processing Unit (CPU), with voice evacuation. The CPU shall communicate with and control the following types of equipment used to make up the system: intelligent detectors, addressable modules, local and remote operator terminals, printers, annunciators, and other system controlled devices. The main FACP shall perform the following functions:

1. Supervise and monitor all intelligent addressable detectors and monitor modules connected to the system for normal, trouble and alarm conditions.
2. Supervise all initiating, signaling, and notification circuits throughout the facility by way of connection to monitor and control modules.
3. Detect the activation of any initiating device and the location of the alarm condition. Operate all notification appliances and auxiliary devices as programmed.
4. Visually and audibly annunciate any trouble, supervisory or alarm condition on operator's terminals, panel display, and annunciators.

C. System Capacity and General Operation: The system shall have the following capacities and general operation modes:

1. The FACP shall be capable of connecting to the number of devices shown on drawings or capable of expansion to 198 intelligent/addressable devices per SLC and 2048 annunciation points per system, whichever is greater. The number of SLCs provided shall be as indicated on the Drawings. Each SLC shall not carry more than 75% of its load capacity.

2. The FACP shall include a full featured operator interface control and annunciation panel that shall include a backlit, 80 character liquid crystal display, individual, color coded system status LEDs, and an alphanumeric keypad for the field programming and control of the fire alarm system.
3. All programming or editing of the existing program in the system shall be achieved without special equipment and without interrupting the alarm monitoring functions of the fire alarm control panel.
4. The FACP shall be able to provide the following features:

Upload/Download to PC Computer	Charger Rate Control
Alarm Verification with Tally	Drift Compensation
Automatic Day/Night Sensitivity Adjust	Device Blink Control
Pre-alarm Control Panel Indication	Trouble Reminder
NFPA Smoke Detector Sensitivity Test	Walk Test
System Status Reports	Periodic Detector Test
Alarm Verification, by device, with tally	Multiple Printer Interface
Multiple CRT Display Interface	Security Monitor Points
Non-Alarm Module Reporting	Block Acknowledge
Smoke Detector Maintenance Alert	Control-By-Time

D. Central Processing Unit: The Central Processing Unit (CPU) shall communicate with, monitor, and control all other modules within the control panel. Removal, disconnection or failure of any control panel module shall be detected and reported to the system display by the CPU.

1. The CPU shall contain and execute all control-by-event (including ANDing, ORing, NOTing, CROSSZONEing) programs for specific action to be taken if an alarm condition is detected by the system. Such control-by-event programs shall be held in non-volatile programmable memory, and shall not be lost with system primary and secondary power failure. The CPU shall also provide a real-time clock for time annotation of all system displays. The Time-of-Day and date shall not be lost if system primary and secondary power supplies fail.
2. The CPU shall be capable of being programmed on site without requiring the use of any external programming equipment. Systems that require the use of external programmers or change of EPROMs are not acceptable.
3. The CPU and associated equipment are to be protected so that they will not be affected by voltage surges or line transients consistent with UL standard 864. □□

E. Display: The system display shall provide all the controls and indicators used by the system operator and may also be used to program all system operational parameters. The display assembly shall contain, and display as required, custom alphanumeric labels for all intelligent detectors, addressable modules, and software zones.

1. The system display shall provide an 80-character back-lit alphanumeric Liquid Crystal Display (LCD). It shall also provide five Light-Emitting-Diodes (LEDs), that will indicate the status of the following system parameters: AC POWER, SYSTEM ALARM, SYSTEM TROUBLE, DISPLAY TROUBLE, and SIGNAL SILENCE.
2. The system display shall provide a 25-key touch key-pad with control capability to command all system functions, entry of any alphabetic or numeric information, and field programming. Two different password levels shall be accessible through the display interface assembly to prevent unauthorized system control or programming.
3. The system display shall include the following operator control switches: SIGNAL SILENCE, LAMP TEST, RESET, and ACKNOWLEDGE.

F. Signaling Line Circuit (SLC) Interface Board: The FACP shall contain SLC interface boards as required to communicate with the SLC loops as shown on the Drawings. Each SLC board shall monitor and

control a minimum of 198 intelligent addressable devices. This includes 99 analog detectors (Ionization, Photoelectric, or Thermal) and 99 monitor or control modules.

1. Each SLC interface board shall contain its own microprocessor, and shall be capable of operating in a local mode (any SLC input activates all or specific SLC outputs) in the event of a failure in the main CPU of the control panel. The SLC interface board shall not require any jumper cuts or address switch settings to initialize SLC Loop operations. SLC interface boards shall provide power and communicate with all intelligent addressable detectors and modules connected to it's SLC Loop on a single pair of wires. This SLC Loop shall be capable of operation as NFPA Style 4, Style 6, or Style 7.
2. Each SLC interface board shall receive analog information from all intelligent detectors and shall process this information to determine whether normal, alarm, or trouble conditions exist for that particular detector. The SLC interface board software shall include software to automatically maintain the detector's desired sensitivity level by adjusting for the effects of environmental factors, including the accumulation of dust in each detector. The analog information may also be used for automatic detector testing and for the automatic determination of detector maintenance requirements.

G. System manual evacuation signal and paging control:

1. The system shall provide dual audio output which shall allow the evacuation signal and prerecorded message to be transmitted over selected circuits while simultaneously permitting paging to be transmitted over other selected circuits.

2. Each signal circuit shall have three manually selected modes.

   a. Automatic mode; the circuit shall operate in its preprogrammed, selective evacuation signal and prerecorded message sequence.
   b. Manual evacuation mode; the circuit shall transmit the evacuation signal and prerecorded message upon manual selection at the fireman's control and status panel.
   c. Paging mode; when the paging mode is selected during either automatic or manual evacuation mode, the evacuation signal shall continue to sound until the microphone button is pressed for a paged signal. Once the microphone button is released, the evacuation tone shall again sound when in the manual or automatic evacuation mode. When not in automatic or manual evacuation, the paging mode shall operate as described without the prerecorded evacuation signal.

3. Each circuit shall be provided with a visual indicator to indicate that the evacuation/prerecorded message sequence is being transmitted and a second indicator to indicate that paging or the alerting signal is being transmitted.

4. A function selector switch shall permit emergency voice and alarm transmission to be made to selected areas by the use of zone selection switches. The alarm tone shall continue to sound in those zones not selected for voice transmission.

   a. The function selector switch shall allow all alarm tones to be silenced and selective voice transmission only shall be permitted via zone selection switches.
   b. If the function selector switch is not returned to the normal position, prior to closing the access panel, an audible and visual trouble signal shall be initiated.
   c. Facility for total building evacuation or paging shall be accomplished by means of a dual function "all circuit" switch.
   d. Each alarm zone shall be provided with an individual selection switch for the purpose of selective voice and/or tone transmission. Zone selection switches shall be maintained

contact type with visual indication operation. The voice communication system shall have provision for at least a separate zone for the following:

1) Exit doors (one zone each corridor).

H. Serial Interface Board: The FACP shall contain a serial interface board to provide an EIA-232 interface between the fire alarm control panel and the UL Listed Electronic Data Processing (EDP) peripherals. The serial interface board shall allow the use of multiple printers, CRT monitors, and other peripherals connected to the EIA-232 ports. In addition, the serial interface board shall provide one EIA-485 port for the serial connection to annunciation and control subsystem components; LEDs shall be provided to show operational status. All serial interface input/outputs shall be optically isolated to provide protection from surges and/or earth grounds.

I. Operators Terminal: Provide an operators terminal which allows the following minimum functions. In addition, the operators terminal shall support any other functions required for system control and/or operation:

1. Acknowledge (ACK/STEP) Switch
2. Signal Silence Switch
3. System Reset Switch
4. System Test Switch
5. Lamp Test Switch

J. Remote Transmissions: The FACP shall be interfaced to a NFPA 72 type, dual-line Digital Alarm Communications Transmitter (DACT) for transmission of its fire alarm, supervisory, and trouble signals to the Owner's designated receiving station. Provide a DACT which is fully compatible and is capable of proper call in, signal exchange and disconnect with the receiving equipment. DACT shall be provided with integral rechargeable batteries with automatic charger. Unit shall perform a self test once every 24 hours. Failure shall initiate a local trouble. Loss of any telephone line shall initiate a local trouble. Trouble signal for AC power loss must not be sent unless maintained for 6 hours or more. The following signals, in order of precedence shall be reported as applicable:

1. Fire.
2. Waterflow.
3. Supervisory.
4. Trouble.

K. Power Supply: The FACP power supply(ies) shall operate on 120 VAC, 60 Hz circuit with dedicated ground and shall have a continuous rating adequate to power all equipment and functions in full alarm continuously. All modules and drivers must be able to withstand prolonged short circuits in the field wiring, either line-to-line or line-to-ground, without damage. Further, the power supply shall be expandable for additional notification appliance power in 3.0 Ampere increments.

1. The power supply shall provide a battery charger for 60 hours of standby using dual-rate charging techniques for fast battery recharge.

L. Emergency Power Supply: Components include batteries, charger, and an automatic transfer switch.

1. Batteries. Sealed maintenance-free lead calcium construction with fully gelled electrolyte.
   a. Battery Nominal Life Expectancy: 15 years, minimum.
   b. Battery Capacity: Comply with NFPA 72. Under maximum quiescent load (system functioning in a non-alarm condition), the secondary supply shall have sufficient capacity to operate the entire system for 60 hours; and at the end of that period, shall be capable of operating all alarm notification appliances used for evacuation or to direct aid to the location of the emergency for 15 minutes.
   c. Magnetic door holders are not served by emergency power. Magnetic door holders are released (after 60 secs) when normal power fails.

d. Battery Calculations: Calculations must be based on the most distant notification appliance on each circuit such that the voltage level at the end of 60 hours of monitor and 15 minutes of alarm is greater than the listed minimum operating voltage for that appliance.

2. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Provide capacity for 150 percent of the connected system load while maintaining batteries at full charge. If batteries are fully discharged, the charger recharges them completely within four hours. Charger output is supervised as part of system power supply supervision.

3. Integral Automatic Transfer Switch: Transfers the load to the battery without loss of signals or status indications when normal power fails.

M. Enclosures: The FACP shall be housed in a UL listed cabinet suitable for surface or semi-flush mounting. Cabinet and front shall be corrosion protected, given a rust-resistant prime coat, and manufacturer's standard finish. The door shall provide a key lock and shall include a glass or other transparent opening for viewing of all indicators. For convenience, the door may be hinged on either the right or left side (field selectable).

2.3 EMERGENCY VOICE/ALARM COMMUNICATIONS SYSTEM

A. As indicated on the drawings provide emergency voice communication systems with the following characteristics and features:

1. Systems with voice capability shall comply with NFPA 72 concerning one-way Public Address (PA) emergency communications, especially with regards to survivability requirements. Provide dual riser systems as required to comply.

2. One-way voice/alarm systems shall be dual channel, permitting the application of an evacuation signal to one or more zones simultaneously with manual voice paging to the other zones. Communication zones shall be capable of being selected in any combination.

3. Control module shall be provided, which contains a central oscillator motherboard, microphone inputs and dual channel mixer/pre-amplifier circuits necessary for proper system operation. Provide two (2) in-phase alarm oscillators and two (2) independent auxiliary oscillators. Provide Slow Whoop alarm oscillators which make a slowly ascending tone from 200 to 830Hz in 2.5 seconds.

4. Dual pre-amplifier module shall provide continuous supervision of the dual pre-amplifier, dual alarm oscillators and microphone output levels. This module shall provide individual channel "trouble" LED's, automatic monitoring and switching for all system amplifiers.

5. A hand-held, push-to-talk microphone with self-winding five-foot coiled extension cable shall be recessed within a protective panel-mounted enclosure at the Main Control Panel. The microphone shall be a noise-canceling communication type with a frequency range of 200 to 4,000Hz.

6. A control switch module shall be furnished to provide manual access for authorized fire-fighting personnel of the audio control module functions. Include "all circuits", "manual alarm", "auxiliary 1 tone", "auxiliary 2 tone", "oscillator stop", and "audio trouble reset" pushbuttons.

7. Provide switches for manual speaker circuit selection.

8. Dual channel message player shall provide a prerecorded evacuation message and shall contain switching circuits, volume control, trouble indication, selection switches, test switch, and speaker.

9. Provide duplicate tone oscillators, pre-amplifiers, and power amplifiers. In the event of an amplifier, a pre-amplifier or a tone oscillator failure, the system shall automatically switch all functions performed by that failed unit to an assigned standby unit.

10. Normal amplifier power shall be a minimum of 125% of the full speaker load, per channel. For calculation purposes use the amplifiers continuous two-tone output rating and the designed power setting for each speaker. A copy of this calculation shall be provided as part of the submittals.

11. At least one back up amplifier shall be provided for each transponder location. The minimum backup power shall be equal to the largest amplifier served from the transponder. Failure of any amplifier shall automatically result in the defective unit being switched offline and replaced with the backup.

12. The system panel shall include a local speaker and switch for testing the prerecorded message.

2.4 VOICE AMPLIFIER CABINET (TRANSPONDER)

A. Wherever a Voice Amplifier Cabinet (Transponder) is indicated on the drawings, provide a UL listed, modular, programmable, microprocessor-based network interface remote panel with the following features for a distributed network fire alarm system. The FTR shall control all notification appliance circuit extender panels within the zone of transponder service and/or auxiliary control outputs. Provide audible voice evacuation signal speaker amplifiers, dual channel paging amplifiers, intelligible voice drivers, power supplies, batteries, hardware, and standby amplifiers for capacity as required for the Base speakers, specified future Tenant devices, and 25% spare within Fire Alarm Transponder panels. The fire alarm transponder typical area of service shall include the floor the transponder is located on, and where transponder capacity allows, one floor above, and one floor below. Refer to the Fire Alarm Riser Diagram for additional information and transponder quantities.

2.5 ALARM APPLIANCES

A. Speakers shall be located as shown on the Drawings; speakers located outdoors shall be listed for use in wet locations. Speakers shall have the following specifications:

1. Voltage: Speakers shall operate on 25V or 70.7V RMS nominal.
2. Programming: Speakers shall be field programmable without the use of special tools to provide multiple sound levels from 0.25 to 2.0 Watts.
3. Sound Level: Speakers shall have a sound level of at least 90 dBA measured at 10 feet from the device and have a frequency range of 400 to 4,000 Hz.
4. Mounting: Provide flush mounting devices suitable for mounting in a standard single gang device box unless otherwise indicated on the Drawings. Mount devices at heights indicated on plans or 6" Below Finished Ceiling (BFC), whichever is lower.

B. Strobe Lights shall be located as shown on the Drawings. Strobe lights indicated for use at exterior of the building shall be mounted at the indicated elevation and listed for use in wet locations. Strobe lights shall have the following specifications:

1. Voltage: Strobe lights shall operate on 24 VDC nominal.
2. Programming: Strobes shall field programmable without the use of special tools to provide 15/75, 30, 75, and 110 Candela output.
3. Maximum pulse duration: 2/10ths of one second.
4. Mounting: Provide flush mounting devices suitable for mounting in a standard single gang device box unless otherwise indicated on the Drawings. Mount devices at heights indicated on plans or 6" Below Finished Ceiling (BFC), whichever is lower.
5. Strobe intensity and flash rate: Must meet minimum requirements of UL 1971. Provide strobe lights with specific intensity Candela (Cd) rating if such is indicated adjacent to the device symbol on the Drawings.
6. Strobes shall be synchronized

C. Audible/Visual Combination Devices shall be located as shown on the Drawings and shall comply with all applicable requirements for both Programmable Electronic Sounders and Strobe Lights. Mount devices at heights indicated on plans or 6" Below Finished Ceiling (BFC), whichever is lower.

D. Device Finish:
1. Ceiling-Mount: Red
2. Wall-mount: Red

2.6 INITIATING DEVICES

A. Addressable Devices - General: Unless otherwise indicated on the Drawings all initiating devices shall be individually addressable. Addressable devices shall comply with the following requirements:

1. Address Setting: Addressable devices shall provide an address-setting means that use rotary decimal switches configured to provide decade (numbered 1 to 10) type addresses.
2. Connections: Addressable devices shall be connected to a Signaling Line Circuit (SLC) with two (2) wires. Signaling Line Circuits shall originate as indicated on the Riser Diagram shown in the Drawings.
3. Operational Indications: Addressable initiation devices shall provide dual alarm and power LEDs. Both LEDs shall flash under normal conditions, indicating that the device is operational and in regular communication with the control panel. Both LEDs shall be placed into steady illumination by the FACP to indicate that an alarm condition has been detected. The flashing mode operation of the detector LEDs shall be optional through the system field program. An output connection shall also be provided in the device base to connect an external remote alarm LED.
4. Intelligent Initiation Devices: All smoke detectors shall be the "intelligent" in that smoke detector sensitivity shall be set through the FACP and shall be adjustable in the field through the field programming of the system. Sensitivity shall be capable of being automatically adjusted by the FACP on a time-of-day basis. Using software in the FACP, detectors shall be capable of automatically compensating for dust accumulation and other slow environmental changes that may affect performance. The detectors shall be listed by UL as meeting the calibrated sensitivity test requirements of NFPA Standard 72, Chapter.
5. Device mounting Base: Unless otherwise specified all detectors shall be ceiling- mount and shall include a separate twist-lock base with tamper proof feature.
6. Sounder Base: Where indicated on the Drawings, provide bases with a built-in (local) sounder rated at 85 dBA minimum. Configure sounder bases such that sounders are activated under conditions as described or otherwise indicated on the Drawings.
7. Test Means: The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a magnetic switch) or initiated remotely on command from the control panel when in the "test" condition.
8. Device Identification: Detectors shall store an internal identifying type code that the control panel shall use to identify the type of device. Device identifications shall be ether PHOTO or THERMAL.

B. Pull Stations: Addressable type, pull stations shall, on command from the Control Panel, send data to the panel representing the state of the manual switch. They shall use a key operated test-reset lock, and shall be designed so that after actual emergency operation, they cannot be restored to normal use except by the use of a key. Pull stations that employ a glass break rod are not acceptable.
1. Pull stations shall have a dual-action mechanism requiring two actions to initiate alarm.
2. All pull stations shall have a positive, visual indication of operation and utilize a double pole, double throw key type reset.
3. Construction: Pull stations shall be constructed of Lexan or other material suitable to the installation environment with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in raised letters, 1.75 inches or larger. Stations shall be suitable for surface mounting or semiflush mounting as shown on the plans. Mount devices at heights indicated on plans.
4. Indoor Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.

C. Photoelectric Smoke Detectors: Photoelectric smoke detectors shall use the photoelectric (light-scattering) principal to measure smoke density and shall, on command from the control panel, send data

to the panel representing the analog level of smoke density. Unless otherwise indicated on the Drawings all smoke detectors shall be photoelectric type.

1. Plug-in Arrangement: Detector and associated electronic components are mounted in a module that connects in a tamper-resistant manner to a fixed base with a twist-locking plug connection. Terminals in the fixed base accept building wiring.

D. Thermal Detectors: Thermal Detectors shall be intelligent addressable devices rated at 200°F. (93° C.) and unless otherwise indicated on the Drawings shall have a rate-of-rise element rated at 15° F. (9.4° C.) per minute. Thermal detectors shall use an electronic sensor to measure thermal conditions caused by a fire and shall, on command from the control panel, send data to the panel representing the analog level of such thermal measurements.

1. Plug-in Arrangement: Detector and associated electronic components are mounted in a module that connects in a tamper-resistant manner to a fixed base with a twist-locking plug connection. Terminals in the fixed base accept building wiring.

E. Non-Rate of Rise Detectors: Where indicated on the Drawings provide thermal detectors with non-rate of rise thermal elements. Non-rate of rise detectors are indicated by NRR adjacent to the thermal detector symbol.

F. Carbon Monoxide Detectors with Sounder Base: Carbon monoxide detectors shall sense concentrations of carbon monoxide with an electrolytic sensing module and shall, on command from the control panel, send data to the panel representing the analog level of the carbon monoxide density.

1. Plug-in Arrangement: Detector and associated electronic components are mounted in a module that connects in a tamper-resistant manner to a fixed base with a twist-locking plug connection. Terminals in the fixed base accept building wiring.
2. Carbon monoxide detectors shall emit a distinct tone upon detection of carbon monoxide.
    a. Evacuation signal shall be a temporal pattern described in NFPA 72 as approved by the authority having jurisdiction

G. Duct Smoke Detector: In-Duct Smoke Detector Housings shall accommodate either an intelligent ionization sensor or an intelligent photoelectric sensor as described elsewhere. The device, independent of the type used, shall provide continuous analog monitoring and alarm verification from the panel. When sufficient smoke is sensed, an alarm signal shall be initiated at the FACP. Unless otherwise indicated on the Drawings all duct smoke detectors shall be photoelectric type

1. Installation: Duct detectors and related items shall be furnished and connected by the Division 26 (Electrical) Contractor but installed by the Division 23 (Mechanical) Contractor.
2. Each duct detector installation shall have a hinged or latched access panel, 12”x12” minimum, for sampling tube inspection and cleaning. Coordinate with Mechanical Contractor.

2.7 MISCELLANEOUS SYSTEM ITEMS

A. Addressable Dry Contact Monitor Module: Addressable Monitor Modules shall be provided to connect one supervised IDC zone (either Style D or Style B) of conventional Alarm Initiating Devices (any Normally Open [N.O.] dry contact device) to one of the Fire Alarm Control Panel Signaling Line Circuit Loops. Monitor modules shall be installed as required by the system configuration. All required monitor modules may not be shown on the Drawings.

1. Indication of Operation: Unless otherwise indicated on the Drawings an LED shall be provided that shall flash under normal conditions, indicating that the Monitor Module is operational and in regular communication with the control panel.
2. Mounting Requirements: Monitor Modules shall mount in a standard 4-inch square, 2-1/8" deep electrical boxes.
3. Location Requirements: Monitor Modules shall be located within conditioned space.

B. Two Wire Detector Monitor Module: Addressable Monitor Modules shall be provided to connect one supervised IDC zone, either Class A or B (Style D or Style B operation) of conventional 2- wire smoke detectors or alarm initiating devices (any N.O. dry contact device) to one of the Fire Alarm Control Panel Signaling Line Circuit Loops. Monitor modules shall be installed as required by the system configuration. All required monitor modules may not be shown on the Drawings.

1. Indication of Operation: Unless otherwise indicated on the Drawings an LED shall be provided that shall flash under normal conditions, indicating that the Monitor Module is operational and in regular communication with the control panel.
2. Mounting Requirements: Monitor Modules shall mount in a standard 4-inch square, 2-1/8" deep electrical boxes.
3. Location Requirements: Monitor Modules shall be located within conditioned space.

C. Addressable Control Module: Addressable Control Modules shall be provided to supervise and control the operation of one conventional Notification Appliance Circuit (NAC) of compatible, 24 VDC powered, polarized Audio/Visual (A/V) Notification Appliances. For fan shutdown and other auxiliary control functions, the control module may be set to operate as a dry contract relay. The control module shall provide address-setting means using decimal switches and shall also store an internal identifying code that the control panel shall use to identify the type of device. An LED shall be provided that shall flash under normal conditions, indicating that the control module is operational and is in regular communication with the control panel.

1. Mounting Requirements: Control Modules shall mount in a standard 4-inch square, 2-1/8" deep electrical boxes.
2. Configuration: The control module NAC circuit may be wired for Style Z or Style Y (Class A/B) with up to 1 Amp of inductive A/V signal, or 2 Amps of resistive A/V signal operation, or as a dry contact (Form C) relay. The control module shall be suitable for pilot duty applications and rated for a minimum of 0.6 amps at 30 VDC. The relay coil shall be magnetically latched to reduce wiring connection requirements, and to insure that 100% of all auxiliary relay or NACs may be energized at the same time on the same pair of wires.
3. Location Requirements: Monitor Modules shall be located within conditioned space.
4. Power Source: Audio/visual power shall be provided by a separate supervised power loop from the main fire alarm control panel or from a supervised, UL listed remote power supply. A/V power sources and connections are not shown on the Drawings.
5. Test Switch: A magnetic test switch shall be provided to test the module without opening or shorting its NAC wiring.

D. Isolator Module: Isolator Modules shall be provided to automatically isolate wire-to- wire short circuits on an SLC loop. The Isolator Module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC Loop.

1. Operation: Isolator Modules shall operate such that if a wire-to-wire short occurs, the Isolator module shall automatically open-circuit (disconnect) the SLC loop. When the short circuit condition is corrected, the Isolator Module shall automatically reconnect the isolated section. The Isolator Module shall not require any address-setting, and its operations shall be totally automatic. It shall not be necessary to replace or reset an Isolator Module after its normal operation.
2. Mounting: The Isolator Module shall mount in standard 4-inch square, 2-1/8" deep electrical boxes. It shall provide a single LED that shall flash to indicate that the Isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.
3. Isolation Modules shall be mounted at the same height as required for A/V devices.

E. Remote Display Annunciator: The Alphanumeric display annunciator shall be a supervised, remotely located back-lit LCD display containing a minimum of eighty (80) characters for alarm annunciation in clear English text. The LCD annunciator shall display all alarm and trouble conditions in the system and

duplicate manual switching functions of the FACP, including acknowledging, silencing, reset, and test. The remote annunciator shall also have a LED graphic display panel mounted adjacent to the LCD display.

1. System Capacity: The system shall allow a minimum of four LCD annunciators. In addition to annunciation functions, each LCD annunciator shall be capable of the following software programmed system functions: Acknowledge, Signal Silence and Reset.
2. Connections: The annunciator shall connect to a two-wire EIA-485 interface. The two-wire connection shall be capable operation at distances of 6,000 feet. Provide interface to fiber optic cable systems and/or repeater units where such are indicated on the Drawings.
3. Protection: The annunciator shall be outfitted with a full Lexan cover on hinged door with locking key access.
4. A hand held, push to talk microphone with self-winding five foot coiled extension cable shall be recessed within a protective panel mounted enclosure at the remote display annunciator. The microphone shall be a noise canceling communication type with a frequency range of 200 to 4,000Hz.

F. Zone Map: Zone maps shall show entire building layout. Room numbers shall reflect actual building signage, not architectural room numbers. Zone maps shall be large enough scale to read device labels and room names/numbers easily and clearly. Do not display notification appliances on zone maps.

1. Frame
   a. Size: 24”x36”
   b. Frame Type: Black, wooden, thin profile (≤1”). Sturdy backboard.
   c. Glazing: Clear, UV-resistant, plastic.
2. Drawings
   a. Drawings shall be prepared independently by the contractor. They shall not be a reprint of the contract documents. Drawings should be easy to read and free from clutter.
   b. Scale: Scale for zone maps shall be reduced as compared to the contract documents to reduce the number of maps required.
   c. Max. Quantity: 4 maps (prior approval required for additional maps).
   d. Colors: Colors shall be limited to the following:
      1) Background: Monochromatic, black and gray, thin lineweight
      2) Fire Alarm Symbols: Red, thick lineweight
      3) Room Numbers and Device Addresses: Solid, not screened. Medium lineweight.
   e. Text Size: Minimum text size for legends, room names/numbers, and device addresses is 1/8” as printed.
   f. Content: Extraneous information shall be removed. Include the following
      1) FA Equipment (FACP, FAAP, FATC, NAC Panels)
      2) FA Initiating devices
         a) Site: Include any devices on site such as PIV Valve, Fire Pump, Fire Protection Backflow preventer devices, etc. (Site devices may be shown in relative location at nearest corner of building, site device locations do not have to be to scale). Include text indicating approximate distance and direction from building.
      3) FA Device Addresses
      4) Background: Walls, Doors, Plumbing Fixtures/Partitions, Casework, Court Striping (Gymnasiums), Exterior Sidewalks/Paving (limit to areas where it is beneficial for clarity).
      5) Symbol Legend
      6) Project Information (Facility Name, Facility Address, Install Date, Key Plan, North Arrow, Sheet/Area Titles, Match lines)
      7) “YOU ARE HERE” designation, varies by zone map location.
      8) Do not include

a) Non-fixed furniture
b) Landscaping/vegetation
c) Finishes
d) Ceiling Grid/Types
e) Structural Items (Beams, trusses, or similar).

3. Zone Map Mounting
   a. FAAP – Mount Zone Maps in frame(s) on wall adjacent to Fire Alarm Annunciator Panel
   b. FACP – Mount Zone Maps in frame(s) on wall adjacent to Fire Alarm Control Panel
   c. Exceptions: Owner approval required prior to installation and will be reviewed on a case-by-case basis.

G. Remote Annunciator Indicator Lights (RAIL): Remote annunciator indicator lights shall be provided in locations where indicated on the Drawings. RAILs shall be provided with a key type switch for testing of the annunciated device. In addition, RAILs shall have the following features:

1. Voltage: RAILs shall operate on 24 VDC nominal.
2. Mounting: Provide flush mounting devices suitable for mounting in a standard single gang device box unless otherwise indicated on the Drawings. Unless otherwise indicated on the Drawings, RAILs shall be mounted as described for electronic sounders above.

H. Door Hold-Open Magnets: Door hold open magnets shall be suitable for mounting in a single gang electrical device box. Door hold open magnets shall be furnished with keepers, door chains, and other accessories as required to properly hold open doors as indicated on the Drawings. Holding force of the magnet shall be appropriate for the door to be held open. Proper attachment of door magnet hardware to doors is the responsibility of the Division 26 Contractor. Door hold open magnets shall operate in a fail safe manner, *i.e.*, the door shall release in event of a failure of voltage to the device.

1. Door hold open magnets: Door hold open magnets shall be configured to operate from a nominal 24 VDC system and shall be powered from the FACP. Magnets shall automatically de-energize when loss of power is occurred at the FACP.
2. Device box support: Door hold open magnet device boxes shall be securely attached to the building structure by means of wood blocking or other equally effective means. Boxes attached directly to only one metal stud or boxes supported by means of expansion type fasteners are not acceptable.

I. SPD: The system shall be equipped with the following protective devices to prevent damage or nuisance alarms by nearby lightning strikes, stray currents, or voltage transients. The devices are to be provided by the fire alarm equipment supplier:

1. On AC Input: A feed-through (not a shunt-type) branch circuit transient arrestor such as the Ditek DTK-DF120S1 or equivalent UL Listed device. Install in a listed enclosure near the electrical panelboard and trim excess lead lengths. Where required/recommended by manufacturer, wind small coil in the branch circuit conductor, within panelboard, downstream of the suppressor connection. Coil is to be about 1" diameter, 5 to 10 turns, and tie-wrapped (or as directed by manufacturer).
2. On DC Circuits Extending Outside Building: Adjacent to the FACU, and also near point of entry to outlying building, provide "pi"-type filter on each leg, consisting of a primary arrestor, series impedance, and a fast acting secondary arrestor which calmps between 30 and 40 Volts. Basis of Design: Ditek DTK-2MHLP or equivalent UL Listed device.

J. Wire
1. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, THHN/THWN, color-coded insulation.
   a. Low-Voltage Circuits: No. 18 AWG, minimum.

b. Line-Voltage Circuits: No. 12 AWG, minimum.

2. Power-Limited Circuits: NFPA 70, Types FPL, FPLR, or FPLP, as recommended by manufacturer. Data Loop wire shall be shielded pair #18 AWG, 30 pf/ft capacitance or less, unless specifically prohibited by the equipment manufacturer and stated on the wiring submittal.

PART 3 - EXECUTION

3.1 FIRE ALARM SYSTEM INSTALLATION AND CONFIGURATION

A. Installation of the FACP and connection of all circuits shall be performed by person meeting requirements listed in Quality Assurance paragraph.

1. All connections at the FACP must be made by the Manufacturer's authorized, factory trained representative (rather than by the electrical contractor).

B. All equipment and components shall be installed in strict compliance with manufacturers' recommendations. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc., before beginning system installation.

1. All system components shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place *(e.g*., detectors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load. Adhesives are not permitted to mount fire alarm system components to building surfaces or structure.

C. Circuit Breaker serving FACP shall be lockable and locked in the “ON” position.

D. All addressable loop controller circuits must be "Class A" and shall have a minimum of 20% spare addresses for future use. "T-taps" from the loop are not permitted. To minimize the impact of a wiring fault on the system, isolation modules must be provided as follows:

1. For each circuit extending outside the building.
2. Within 15 feet of the FACP, at each end of the loop.
3. At the Terminal Cabinet, at each end of the loop.
4. Minimal of (1) midway through the loop address scheme. Additional modules shall be provided after each 25 devices or control points on each addressable circuit.
5. Isolation modules not located at the FACP shall be mounted readily visible in unfinished spaces (i.e. electrical rooms, mechanical rooms, and janitorial closets) only at same height as audio/visual devices.

E. Manual Pull Stations shall be mounted semi-flush within recessed back boxes

F. Visible signals must be the strobe (flash discharge) type, with white or clear lens, and shall comply with current ADA requirements for intensity, placement, and synchronization.

G. The FACP must have an Alarm Silence switch, and be equipped with the Subsequent Alarm (alarm resound) feature. Any remote annunciators or graphic displays located away from the alarm area must also include an audible signal with alarm resound feature.

1. Alarm Silence shall not reverse AHU shutdown and disable smoke evacuation system. Provide supervised Hand-Off-Auto switches at the FACP for any smoke control equipment.

H. All supervisory trouble signals shall be different and distinct from a normal system trouble and shall be non-silenceable.

I. Provide a supervised “AHU Shutdown Defeat” toggle switch in the FACP. Provide an informative engraved label at switch indicating “Normal” position. The switch must cause a system “trouble” indication when it is placed in the off (“Shutdown Defeated”) position.

J. Wiring Method: Install wiring in metal raceway according to Division 26 Section "Raceways and Boxes." Conceal raceway except in unfinished spaces and as indicated.
1. The exterior of all junction boxes containing fire alarm conductors shall be painted red; box interiors shall not be painted. Box covers for junction boxes containing fire alarm conductors shall be painted red on both sides. All painting of junction boxes and junction box covers shall be accomplished prior to installation of the boxes to avoid possible problems with overspray.
2. Box covers shall be labeled to indicate the circuit(s) or function of the conductors contained therein. Labels shall be neatly applied black lettering on a clear background. Handwritten labels or labels made from embossed tape are not acceptable.
3. Provide metal back boxes or plastic skirts as manufactured by fire alarm manufacture for devices installed in a surface mounted application. Boxes shall match device in size and color.

K. All wiring shall be color coded in accordance with the following scheme, which shall be maintained throughout the system, without color change in any wire run:

Signaling Circuits	Over
Alarm Notification Circuits	Blue (+) and Black (-)
24V System Circuits (HVAC)	Yellow (+) and Brown (-)
Door Control Circuits	Orange

L. Cable Splices: Any and all cable splices shall be in hinged terminal cabinets only. No splicing of conductors in outlet or junction boxes. There shall be NO splices in the system other than at terminal blocks. "Wire nuts," crimp splices, or insulation piercing type connectors are not acceptable. All terminal block screws shall have pressure wire connectors of the self-lifting or box lug type. □□Permanent wire markers shall be used to identify all splices and terminations for each circuit. For splices, use markers or other means to indicate which conductors leads to the FACP.

M. Detection or alarm circuits shall not be installed in raceways containing AC power or AC control wiring. Within the FACP, any 120 VAC control wiring or other circuits with an externally supplied AC/DC voltage above the nominal 24 VDC system power must be properly separated from other circuits and the enclosure must have an appropriate warning label to alert service personnel to the potential hazard.

N. Provide an engraved label on FACP and all notification appliance circuit expansion panels identifying its 120 VAC power source. This label shall include panelboard identification and circuit number and panelboard location.

O. All wiring shall be checked for grounds, opens, and shorts, prior to termination at panels and installation of detector heads. The minimum resistance to ground or between any two conductors shall be ten megohms (10 Mõ), as verified with a megger. Provide advance notice to the Engineer of these tests.

P. The system shall be electrically supervised for open or (+/-) ground fault conditions in SLC, alarm circuits, and control circuits. Removal of any detection device, alarm appliance, plug-in relay, system module, or standby battery connection shall also result in a trouble signal. Fire alarm signal shall override trouble signals, but any pre-alarm trouble signal shall reappear when the panel is reset.

Q. Supervision required: The connection between individual addressable modules and their contract type initiating device(s) must be supervised.

R. Wall-mounted magnetic door holders and separate heavy-duty closers shall be used, instead of combination door control units.

1. The electromagnets shall be controlled by the FACP. Individual smoke detector auxiliary contacts shall not be used to release door holders.

S. Spare Parts: Provide the following spare parts with the system, each individually packaged and labeled. For percentage quantities round number up to the next larger whole number.

Fuses	(2) of each size used in the system
Indoor Speaker/Strobes	4% of installed quantity
Exterior Indicating Devices	4% of installed quantity
Spot Smoke Detector	6% of installed quantity
Spot Heat/Thermal Detectors	6% of installed quantity
Spot Smoke Detectors, Bases	2% of installed quantity
Relay Modules	4% of installed quantity
Monitor Modules	4% of installed quantity
Isolation Modules	4% of installed quantity
Isolation Bases	4% of installed quantity
Manual Stations	2% of installed quantity

3.2 SMOKE DETECTORS

A. Do not install detector heads until building is clean. Provide dust covers for bases throughout construction. Unless suitably protected against dust, paint, etc., detectors shall not be installed until the final construction clean-up has been completed. Contaminated detectors must be REPLACED by the Contractor at no additional cost to the Owner.

B. A spot type smoke detector shall be provided within 15’ from FACP, auxiliary panels, power extenders, NAC expansion panels and other control equipment. As NAC expansion panels and power extenders are not shown on drawings, additional detectors not shown shall be added required to meet this provision.

C. When installed in a room, detectors shall be oriented so their alarm light is visible from the nearest door to the corridor, unless Remote Alarm Indicator Light (RAIL) equipped.

D. Spot type smoke detectors mounted within 12 feet of a walking surface shall have their built-in locking device activated. □□Unless suitably protected against dust, paint, etc., detectors shall not be installed until the final construction clean-up has been completed. Contaminated detectors must be REPLACED by the Contractor at no additional cost to the Owner.

E. Ceiling-Mounted Smoke Detectors: Not less than 4 inches (100 mm) from a side wall to the near edge. For exposed solid-joist construction, mount detectors on the bottom of joists. On smooth ceilings, install not more than 30 feet (9 m) apart in any direction.

F. Wall-Mounted Smoke Detectors: At least 4 inches (100 mm), but not more than 12 inches (300 mm), below the ceiling.

G. Smoke Detectors near Air Registers: Install no closer than 36 inches (1520 mm).

H. All air duct/plenum detectors must have a RAIL located in the nearest corridor or public area and identified by an engraved label affixed to the wall or ceiling. These detectors shall be installed in a manner that provides suitable access for required periodic cleaning and calibration.

I. Duct detector sampling tubes shall extend the full width of the duct. Those over 36 inches long must be provided with rear support. The preferred method for doing this is to have the tube go through the far side of the duct, with the point of penetration tightly sealed to prevent air leakage around the tube. This facilitates smoke testing and tube cleaning. Duct smoke detector mounting position and air sampling tube

orientation, are critical for proper operation. The Manufacturer's detailed installation instructions must be followed. The Contractor shall mark the direction of air flow on the duct at each duct detector location. Each duct detector installation shall have a hinged or latched access panel, 12”x12” minimum, for sampling tube inspection and cleaning. Coordinate with Mechanical Contractor.

J. Smoke detector guards, where indicated on the Drawings shall be Listed for use with the specific model of smoke detector being protected. All smoke detector guards are to have a separate base which must be very securely anchored to wall or ceiling. The cover must be readily removable by the Owner for periodic detector cleaning and servicing but, to prevent unauthorized entry, must be secured to the base by a lock or tamper resistant screws approved by the Engineer. Metal guards must be 16 gauge or heavier steel.

3.3 AUTOMATIC SMOKE DOOR HOLD OPEN MAGNET REQUIREMENTS

A. Wall-mounted magnetic door holders and separate heavy-duty closers shall be used, instead of combination door control units.

B. The electromagnets shall be controlled by the FACP. Individual smoke detector auxiliary contacts shall not be used to release door holders.

3.4 KITCHEN EXHAUST HOOD EXTINGUISHING SYSTEM:

A. Installation shall comply with the current edition of NFPA Standard for the type of system installed.

1. System shall be monitored by the fire alarm system with a separate address
2. The following operational requirements are generally provided directly by the extinguishing system. The contractor shall verify that the means for providing the following operation sequence is in place:
    a. The exhaust fan must continue running after the system has been discharged, except on carbon dioxide systems) to remove smoke; the supply fan should stop running.
    b. All sources of heat for appliances served by the extinguishing system (both electric and/or gas) must be turned off.

3.5 EMERGENCY VOICE/ALARM COMMUNICATIONS

A. Wiring Method: All wiring and cable shall be installed in a minimum ¾” diameter metal raceway according to Division 26 Section "Raceways and Boxes." Conceal raceway except in unfinished spaces and as indicated

B. Riser: All circuits required for the operation of notification appliances shall be protected within ether a 2-hour fire rated enclosure or shall consist of a 2-hour fire rated cable or cable system, until they enter the evacuation signaling zone (floor) that they serve.

C. All One-way Voice Alarm shall be wired with twisted pair copper conductors AWG 18 minimum in shielded cable, Belden 8790, West Penn 293, or equivalent. Cable jacket color shall be gray, with red (+) and black (-) conductor insulation. The shields shall be continuously connected from the amplifiers to the end of line. Tape the shield splice at each speaker and handset, to insulate from ground. All shields shall be single point grounded at the amplifier, unless prohibited by system manufacturer.

D. Each speaker circuit shall be supervised so that an opening in any circuit will result in audible and visual trouble indication.

E. Should the system be unable to transmit the pre-recorded message because of failure, the system shall automatically revert to the fire alarm signal transmission mode.

F. Trouble indicators shall be automatically de-energized during a system alarm condition and reappear when the alarm condition has been reset.

G. Evacuation signal shall be a “three-pulse” temporal pattern complying with ANSI S3.41-1990.

3.6 MULTIPURPOSE AUDIO SOUND SYSTEM AND LIGHTING CONTROL SYSTEM

A. The following functions shall occur upon any general alarm:

1. Disconnect the audio sound system at the stage: Refer to wiring schematic of sound system.

3.7 SPRINKLER SYSTEM MONITORING

A. The following sprinkler system alarm and supervisory functions shall be provided as a part of the fire alarm system:

1. Waterflow alarm, by sprinkler zone (not to exceed one floor).
2. Supervision of each control valve.
3. Supervision of air pressure, if used (both high and low).
4. Supervision of fire pump. Include fire pump running and fire pump power failure, including dead-phase and phase reversal.

B. Sprinkler supervisory monitoring of flow switches, tamper switches, and similar functions shall be accomplished with a separate system address for each activity monitored.

3.8 FIRE ALARM CONTROL PANEL PROGRAMMING

A. Programming of the FACP and connection of all circuits shall be performed by person meeting requirements listed in Quality Assurance paragraph.

B. The complete configuration data (site-specific programming) for the system must be permanently stored on a computer disk and archived by the manufacturer or authorized distributor. A disk copy of this data must be submitted to the Engineer for transmission to the Owner when the system is commissioned.

C. The Manufacturer or authorized distributor must maintain software version (VER) records on the system installed. The system software shall be upgraded free of charge if a new VER is released for any reason during the warranty period. For any new VER to correct problems, free upgrade shall apply during the entire life of the system.

D. The Fire Alarm System shall have multiple access levels which permit the Owner's authorized personnel to make temporary changes in the system alarm response matrix without actually changing the system programming. This must include the ability to override selected alarm inputs or system responses to alarms without affecting the remaining portions of the system.

1. The fire alarm system shall have a self-contained modem with a minimum speed of 9,600 baud for external communications purposes. All system functions and programming features must be available through the modem port. The modem port shall be password protected with multiple access levels as described above.

E. In addition to the system tests and certification described elsewhere, the Manufacturer or authorized distributor must 100% test all site-specific software functions for the system and provide a written test report or detailed check list. This documentation must include a system operation matrix showing the actual FACP response for each initiating device input.

3.9 SYSTEM LABELING

A. Detectors and initiating devices: Identification of individual detectors is required by a unique alphanumeric label. These device labels, which must also be shown on the shop drawings. Identification labels must be printed labels with black lettering on a clear background. Handwritten labels or labels made from embossed tape are not acceptable.
   1. Loop 1 shall be assigned to the lowest floor devices and loop number shall increase with floor number. Device number starts in the same location on each floor and increase accordingly as circuit location increases.
   2. Manual Pull Stations: Labels shall be provided on the pull station and the protective cover.
   3. Detectors (Heat/Smoke/CO): Detector labels shall be permanently affixed to the detector base. Device labels may not be affixed to the device head.
   4. Remote Alarm Indicator Light (RAIL): Label shall indicate device address for the detector served.

B. Notification Appliances: Notification appliances shall be clearly labeled with NAC panel and circuit number. Add “EOL” designation to label where an end-of-line resistor is located in the junction box behind the notification appliance.

C. FACP and System Equipment: Provide an engraved label in FACP identifying its 120 VAC power source. This label shall include panelboard location, identification, and circuit number. Labels shall also be provided for auxiliary panels, NAC panels, and power extenders.

D. Zone Map: Provide framed zone map at FACP and at all remote annunciators.

E. Provide framed basic operating instructions at FACP.

F. Floor Plans with Device Numbers: A copy of the floor plans shall be provided in the control panel. A separate sheet shall be provided for each floor. Plans shall be reduced in size from engineering plans in order to fit on 11x17 sheets. All device addresses shall be clearly labeled on plans. Minimum printed text size shall be 0.75/10”. Indicate location of all cabinets, modules, and end of line resistors. Plans shall be laminated and bound in book form. Provide legend for symbols. Provide holder for plan book in panel or in a locked box adjacent to panel keyed to match panel. Provide label for box and book.

3.10 PHYSICAL PROTECTION

A. Manual pull-stations: Provide indoor protective shield. Lifting the clear plastic cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.

B. Visual alarm appliances: Provide protective wire guards, manufactured specifically for strobes, for all strobes/visual alarm appliances located in gymnasiums, multi-purpose rooms, and other areas where appliances are subject to physical damage. Refer to plans for notation indicating exact locations. Visual alarm appliances located in kitchens shall be direct-spray waterproof.

3.11 CLEANING AND ADJUSTING

A. Cleaning: Remove paint splatters and other spots, dirt, and debris. Touch up scratches and marred finish to match original finish. Clean unit internally using methods and materials recommended by manufacturer. Replace damaged units.

PART 4 - SYSTEM TESTING & CERTIFICATION

4.1 TESTING

A. Pretesting: After installation, align, adjust, and balance the system and perform complete pretesting. Determine, through pretesting, the compliance of the system with requirements of Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones, and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.

1. Minimum System Tests: Minimum test shall be a 100% operation test including, but not limited to the following-
   a. Verify the absence of unwanted voltages between circuit conductors and ground.
   b. Test all conductors for short circuits using an insulation-testing device.
   c. With each circuit pair, short circuit at the far end of the circuit and measure the circuit resistance with an ohmmeter. Record the circuit resistance of each circuit on record drawings.
   d. Verify that the control unit is in the normal condition as detailed in the manufacturer's operation and maintenance manual.
   e. Test initiating and indicating circuits for proper signal transmission under open circuit conditions. One connection each should be opened at not less than 10 percent of initiating and indicating devices. Observe proper signal transmission according to class of wiring used.
   f. Test all initiating and indicating device for alarm operation and proper response at the control unit. Test smoke detectors with actual products of combustion.
   g. All circuits shall be tested for supervision. Signal Line Circuits shall be tested for “Class A”.
   h. All sprinker devices shall be tested for alarm, supervisory and trouble situations.
   i. All control circuits (AHU shutdown, door holders, dampers) shall be tested for proper operation on an alarm condition and for wire supervision.
   j. Check zone map for proper location of all devices. Verify that devices and wire are properly labeled.
   k. Test the system for all specified functions according to the approved operation and maintenance manual. Systematically initiate specified functional performance items at each station, including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequences. Observe indicating lights, displays, signal tones, and annunciator indications. Observe all voice audio for routing, clarity, quality, freedom from noise and distortion, and proper volume level.
   l. Test Both Primary and Secondary Power: Verify by test that the secondary power system is capable of operating the system for the period and in the manner specified.

B. Testing Required by WELDON SCHOOL- Upon completion of the installation the Division 26 Contractor and the Manufacturer’s authorized representative together shall perform a complete system test and submit test documentation to WELDON SCHOOL. The test shall include but not be limited to the following:
   a. All initiating devices shall be tested for alarm. Smoke detectors shall be tested with smoke.
   b. All circuits shall be tested for supervision. Signal Line Circuits shall be tested for “Class A”.
   c. All sprinkler devices shall be test for alarm, supervisory, and trouble situation.
   d. All control circuits (AHU shutdown, door holders, and dampers) shall be tested for proper operation on an alarm condition and for wire supervision.
   e. All notification appliances shall be tested for proper operation, synchronization, and supervision.
   f. Check zone map for proper location of all devices.
   g. Verify that devices and wire are properly labeled.
   h. Verify that the addressable device’s descriptive custom label at the panel corresponds to its actual location. Devices located at fire doors and corridors should have a room number reference (e.g. “Fire doors by room 103 L1S02” or “Exit by room 160 M3-21”).

i. Verify proper system monitoring with SimplexGrinnell. Test that ALARM, WATERFLOW, SPRINKLER SUPERVISORY, and SYSTEM TROUBLE signals were sent and received properly.

C. Report of Pretesting: After pretesting is complete, provide a letter certifying the installation is complete and fully operable, including the names and titles of witnesses to preliminary tests.

D. Engineer's Test: After the pretest has been completed and the system is clear of trouble all test documentation including a printout of all custom labels and a NFPA 72 "Record of Completion" form shall be submitted to Engineer for approval. At that time Engineer may, at his discretion, perform a 100% functional test of the fire alarm system. The Contractor and the Manufacturer's authorized representative that installed the system must be present. Should the results of this test not be satisfactory, then corrections will be made and a re-test will be required at the Contractor's expense.

E. Authority Having Jurisdiction Inspection/Test: Only after Engineer has approved the system the design professional will schedule the inspection. The Contractor and the Manufacturer's authorized representative must be present for test. Provide a minimum of 10 days' notice in writing to the Engineer for the Authority Having Jurisdiction Inspection/Test.

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 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. Submit log on the satisfactory completion of tests.

H. Closeout: After successful completion of inspections and tests, the warranty period begins. In the event of malfunctions or excessive nuisance alarms, the Contractor must take prompt corrective action. The Owner may require a repeat of the Contractor's 100% system test, or other inspections. Continued improper performance during the warranty period shall be cause to require the Contractor to remove and replace the system.

4.2 TEST EQUIPMENT

A. Contractor shall provide two-way radios, ladders, smoke candles or test magnet, and any other materials needed to test the system.

4.3 OWNER'S TRAINING/DEMONSTRATION

A. The Manufacturer's authorized representative shall provide training for the Owner's designated employees in proper operation of the system and in all required periodic maintenance. Scheduling of training must be arranged to meet the Owner's schedule. The instruction shall include a minimum of three (3) copies of a written, bound training summary, for future reference. Basic operating instructions shall be framed and mounted at the FACP.

B. Training shall cover the following topics as a minimum:
1. Preventative maintenance service techniques and schedules, including historical data trending of alarm and trouble records.
2. Overall system concepts, capabilities, and functions. The Owner shall be able to add or delete devices to the system and to take any device out of service and return any device to service without need for Manufacturer's approval.
3. Explanation of all control functions, including training to program and operate the system software.
4. Methods and means of troubleshooting and replacement of all field wiring and devices.

5. Methods and procedures for troubleshooting the main fire alarm control panel, including field peripheral devices as to programming, bussing systems, internal panel and unit wiring, circuitry and interconnections.
6. Manuals, drawings, and technical documentation. Actual system software used for training shall be provided on CD and shall be left with the Owner at the completion of training for the Owner's use in the future.

4.4 DOCUMENTATION

A. The Contractor shall provide the Engineer with three (3) copies of the following:
   1. As-built floor plans with device numbers, wiring and conduit layout diagrams, including wire color code and/or label numbers, and showing all interconnections in the system. Provide on paper and in AutoCAD 2000 or later electronic media format.
   2. Electronic circuit diagrams of all control panels, modules, annunciators, communications panels, etc.
   3. Technical literature on all major parts of the system, including control panels, batteries, detectors, manual stations, alarm indicating appliances, power supplies, and remote alarm transmission means.

B. The Contractor shall provide the Owner with three (3) interconnection cables to connect the fire alarm system to a PC.

4.5 ON-SITE ASSISTANCE

A. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels, controls, and sensitivities to suit actual occupied conditions. Provide up to three requested visits to Project site for this purpose.

END OF SECTION 26 83 11

SECTION 311000 - SITE PREPARATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Standards set forth by the North Carolina Department of Environmental Quality (NCDEQ) Division of Energy, Mineral and Land Resources.

1.2 SUMMARY

A. This Section includes the following:

1. Removal of trees and other vegetation.
2. Clearing and grubbing.
3. Removing above-grade improvements.
4. Removing below-grade improvements.

B. Related Sections:

1. Division 31 Section “Earth Moving".
2. Division 31 Section "Erosion Controls".

1.3 PROJECT CONDITIONS

A. Traffic: Conduct site-clearing operations to ensure minimum interference with roads, streets, walks, and other adjacent occupied or used facilities. Do not close or obstruct streets, walks, or other occupied or used facilities without permission from authorities having jurisdiction.

B. Protection of Existing Improvements: Provide protections necessary to prevent damage to existing improvements indicated to remain in place.

1. Protect improvements on adjoining properties and on Owner's property.
2. Restore damaged improvements to their original condition, as acceptable to property owners.
3. All erosion control measures shall be in place prior to commencement of clearing operations.

C. Protection of Existing Trees and Vegetation: Protect existing trees and other vegetation indicated to remain in place against unnecessary cutting, breaking or skinning of roots, skinning or bruising of bark, smothering of trees by stockpiling construction materials or excavated materials within drip line, excess foot or vehicular traffic, or parking of vehicles within drip line. Provide temporary guards to protect trees and vegetation to be left standing.

1. Water trees and other vegetation to remain within limits of contract work as required to maintain their health during course of construction operations.
2. Provide protection for roots over 1-1/2 inch (38 mm) in diameter that are cut during construction operations. Coat cut faces with an emulsified asphalt or other acceptable coating formulated to use on damaged plant tissues. Temporarily cover exposed roots with wet burlap to prevent roots from drying out; cover with earth as soon as possible.

3. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations in a manner acceptable to Engineer. Employ a licensed arborist to repair damage to trees and shrubs.
4. Replace trees that cannot be repaired and restored to full-growth status, as determined by arborist.

D. Salvageable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated or directed.

1.4 EXISTING SERVICES

A. General: Indicated locations are approximate; determine exact locations before commencing Work.

B. Arrange and pay for disconnecting, removing, capping, and plugging utility services. Notify affected utility companies in advance and obtain approval before starting this Work.

C. Place markers to indicate location of disconnected services. Identify service lines and capping locations on Project Record Documents.

1.5 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Comply with governing EPA notification regulations before beginning demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.

B. Standards: Comply with ANSI/ASSP A10.6 and NFPA 241.

PART 2 – PRODUCTS

None Used.

PART 3 – EXECUTION

3.1 SITE CLEARING

A. General: Remove trees, shrubs, grass, and other vegetation, improvements, or obstructions, as required, to permit installation of new construction. Remove similar items elsewhere on site or premises as specifically indicated. Removal includes digging out and off-site removal of stumps and roots.

1. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
2. Existing trees within clearing limits may be chipped and stockpiled on-site but shall NOT be used as landscaping mulch or fill.

B. Clearing and Grubbing: Clear site of trees, shrubs, and other vegetation, except for those indicated to be left standing.

1. Completely remove stumps, roots, and other debris protruding through ground surface.
2. Use only hand methods for grubbing inside drip line of trees indicated to remain.
3. Fill depressions caused by clearing and grubbing operations with satisfactory soil material, unless further excavation or earthwork is indicated.

a. Place fill material in horizontal layers not exceeding 6 inches (150 mm) loose depth, and thoroughly compact each layer to a density equal to adjacent original ground.

C. Topsoil Stripping: Strip and stockpile existing topsoil within construction limits for re-spreading. Should the Contractor elect to remove topsoil from the site, suitable topsoil from off-site sources shall be provided for re-spreading at no cost to the Owner.

1. Remove sod and grass before stripping topsoil.
2. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials. All surface topsoil, regardless of thickness encountered, shall not be considered Unsuitable Soil.
3. Remove subsoil and non-soil materials from topsoil, including trash, debris, weeds, roots, and other waste materials.
4. Stockpile topsoil materials within construction limits and away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust.
5. Do not stockpile topsoil within tree protection zones.
6. Dispose of excess topsoil off-site.

D. Removal of Improvements: Remove existing above-grade and below-grade improvements as indicated and as necessary to facilitate new construction.

1. Abandonment or removal of certain underground pipe or conduits may be indicated on mechanical or electrical drawings and is included under work of related Division 22 Sections. Removing abandoned underground piping or conduits interfering with construction is included under this section.

3.2 DEMOLITION PREPARATION

A. Conduct demolition operations and remove debris 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 governing regulations or as shown on the drawings.

B. Conduct demolition operations to prevent injury to people and damage to adjacent buildings and facilities to remain. Ensure safe passage of people around selective site demolition area.

1. Erect temporary protection, such as walks, fences, railings, canopies, and covered passageways, where required by authorities having jurisdiction or as shown on the plans.
2. Protect existing site improvements, appurtenances, and landscaping to remain.
3. Erect a plainly visible fence around drip line of individual trees or around perimeter drip line of groups of trees to remain.
4. Provide temporary weather protection, during interval between demolition and removal of existing construction, on exterior surfaces and new construction to ensure that no water leakage or damage occurs to structure or interior areas.

C. Provide and maintain exterior shoring, bracing, or structural support to preserve stability and prevent movement, settlement, or collapse of building to be selectively demolished.

1. Strengthen or add new supports when required during progress of selective demolition.

D. Protect trees, fences, poles, mailboxes, and all other property unless their removal is authorized. Any property damaged, that is not authorized for removal, shall be restored or replaced to the Owner’s satisfaction.

3.3 UTILITY SERVICES

A. Maintain existing utilities indicated to remain in service and protect them against damage during selective site demolition operations.

1. Do not interrupt existing utilities serving occupied or operating facilities, except when authorized in writing by Owner and authorities having jurisdiction. Provide temporary services during interruptions to existing utilities, as acceptable to Owner and to governing authorities.

a. Provide not less than 72 hours' notice to Owner if shutdown of service is required during changeover.

B. Utility Requirements: Locate, identify, disconnect, and seal or cap off indicated utility services serving building to be selectively demolished.

1. Arrange to shut off indicated utilities with utility companies.
2. Where utility services are required to be removed, relocated, or abandoned, provide bypass connections to maintain continuity of service to other parts of the building before proceeding with selective demolition.

C. Utility Requirements: Refer also to Division 21, 22, 23 and 26 Sections for additional requirements for shutting off, disconnecting, removing, and sealing or capping utility services. Do not start selective site demolition work until utility disconnecting and sealing have been completed and verified in writing.

D. Utility Adjustments and Relocations: Adjust locations, elevations and routes of existing utility lines, poles, guys, vaults, handholes, boxes, and other related appurtenances as required to facilitate new construction. Coordinate adjustments and relocations with utility companies.

3.4 POLLUTION CONTROLS

A. Use water mist, temporary enclosures, and other suitable methods to limit the spread of dust and dirt. Comply with governing environmental protection regulations.

1. Do not use water when it may damage existing construction or create hazardous or objectionable conditions, such as ice, flooding, and pollution.

B. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.

C. Clean adjacent structures and improvements of dust, dirt, and debris caused by selective site demolition operations. Return adjacent areas to condition existing before start of selective demolition.

3.5 SELECTIVE SITE DEMOLITION

A. Demolish and remove existing construction only to the extent required by new construction and as indicated on the drawings. Completely demolish and remove existing improvements; including footings, utilities and other below-grade elements; as indicated on the drawings. Use methods required to complete Work within limitations of governing regulations.

1. Dispose of demolished items and materials promptly. On-site storage or sale of removed items is prohibited.
2. Return elements of construction and surfaces to remain to condition existing before start of selective demolition operations.
3. Comply with all applicable regulations during demolition, handling and disposal of all items indicated to be removed or necessary to be removed to allow construction of new work.

B. Demolish asphalt, concrete and masonry in small sections. Cut concrete and masonry at junctures with construction to remain, using power-driven masonry saw or hand tools; do not use power-driven impact tools.

C. Remove sawcut concrete and asphalt, including aggregate base, to a depth of 12-inches below existing, adjacent grade, or as indicated. Provide neat sawcut at limits of pavement removal as indicated.

3.6 PATCHING AND REPAIRS

A. Promptly patch and repair holes and damaged surfaces caused to adjacent construction by selective site demolition operations.

B. Where repairs to existing surfaces are required, match previous work as closely as possible.

1. Completely fill holes and depressions in existing masonry walls to remain with an approved masonry patching material, applied according to manufacturer's printed recommendations.

C. Restore exposed finishes of patched areas and extend finish restoration into adjoining construction to remain in a manner that eliminates evidence of patching and refinishing.

3.7 CLEANING

A. Keep the site free from debris and hazards and inspect the site at the end of each day for trash. All adjacent roads and drives outside of the construction fencing shall remain in operation during construction and shall remain free of all construction materials and debris.

3.8 DISPOSAL OF WASTE MATERIALS

A. General: Promptly dispose of demolished materials. Do not allow demolished materials to accumulate on-site.

B. Burning on Owner's Property: Burning is not permitted on Owner's property.

C. Removal from Owner's Property: Remove waste materials and unsuitable or excess soils and mulch from Owner's property. Transport demolished materials off Owner's property and legally dispose of them.

END OF SECTION 311000

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SECTION 312000 – EARTH MOVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Report of Subsurface Investigation.

1. The geotechnical report is available to bidders as general information with regard to project and site conditions. However, the geotechnical report is not a part of the contract documents and is not a warranty or guarantee of subsurface conditions. Variations in subsurface conditions should be anticipated. Bidders should carefully inspect the site prior to bidding and will be provided reasonable access to perform independent explorations of subsurface conditions, if requested.

1.2 SUMMARY

A. This Section includes the following:

1. Preparing and grading subgrades for walks, lawn areas, and landscaping.
2. Excavating, filling and backfilling for structures.
3. Base course for walks and pavements.
4. Subsurface drainage backfill for trenches.
5. Excavating and backfilling trenches.

B. Related Sections: The following Sections contain requirements that relate to this Section.

1. Division 01 Sections for allowances, definitions and procedures.
2. Division 31 Section "Site Preparation" for site stripping, grubbing, topsoil removal, and tree protection.
3. Division 33 Section “Storm Drainage Utilities” for storm drainage.
4. Division 32 Section "Planting" for finish grading, including placing and preparing topsoil for permanent and temporary grass seeding.
5. Division 31 “Erosion and Sediment Controls”, for all areas of the site that are graded or disturbed by any construction operations

1.3 UNIT PRICES

A. Rock Measurement: Volume of rock actually removed, measured in original position, but not to exceed the following:

1. 24 inches outside of concrete forms other than at footings.
2. 12 inches outside of concrete forms at footings.
3. 6 inches outside of minimum required dimensions of concrete cast against grade.
4. 6 inches beneath bottom of concrete slabs on grade.
5. 6 inches beneath invert elevation of pipe in trenches and 12 inches wider than pipe outside diameter.
6. Additional rock removed beyond the limits outlined above to accommodate trench boxes, other removal methods, compaction equipment or other reasons shall not be included in the payment volume.

7. Any materials paid by Unit Prices to replace excavated rock shall utilize these same measurement limits.

B. Unsuitable Soil Measurement: Volume of soil actually removed, measured in original position, but not to exceed the limits directed by the Owner's Independent Testing Agency.

1. Additional soil excavated beyond the limits directed by the Owner's Independent Testing Agency; including lay-back of excavation walls, excavation to accommodate trench boxes or other shoring, etc.; shall not be considered Unsuitable Soil.

C. Replacement Material Measurement: Volume exactly equal to that of the unsuitable soil or rock that was removed, measured in original position.

D. Unit prices for unsuitable soil and rock removal shall include all work and materials as defined in Division 01 sections.

1.4 DEFINITIONS

A. Excavation consists of the removal of material encountered to subgrade elevations and the reuse or disposal of materials removed. Refer to the following section for additional definitions of classified excavations.

B. Subgrade: The uppermost surface of an excavation or the top surface of a fill or backfill immediately below base course, drainage fill, or topsoil materials.

C. Borrow: Soil material obtained off-site when sufficient approved soil material is not available from excavations.

D. Surface Course: The top layer of the pavement structure placed on base course or subgrade.

E. Base Course: Layer placed between the subgrade elevation and asphalt paving courses.

F. Bedding Course: Layer placed over excavated subgrade in a trench before laying pipe.

G. Unauthorized excavation consists of removing materials beyond indicated subgrade elevations or dimensions without direction by the Architect. Unauthorized excavation, as well as remedial work directed by the Architect, shall be at the Contractor's expense.

H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below ground surface.

I. Structural Areas: Areas containing Structures and pavement and extending 10-ft beyond the limits of structures and pavements. Structural Areas in fill shall also include the area supporting the fill slope along a 1:1 slope to existing grade. Pavement areas include but are not limited to roads, driveways, parking lots, curbs, sidewalks, dumpster pads, equipment pads, concrete pads, tracks, tennis courts, and other similar above grade improvements.

J. Utilities include on-site underground pipes, conduits, ducts, and cables, as well as underground services within building lines.

1.5 EXCAVATION CLASSIFICATIONS

A. Excavation Classifications: All excavation is classified as General Excavation except for Mass Rock, Trench Rock and Unsuitable Soil Materials as defined in this section.

1. General Excavation: Excavation, removal and/or disposal of pavements and other obstructions visible on surface; underground structures, utilities, and other items indicated to be demolished and/or removed; together with soil, boulders, and other materials encountered that are not classified as rock, unsuitable soil, or unauthorized excavation.

    a. Intermittent drilling, blasting, or ripping to increase production and not necessary to permit excavation of material encountered will be considered general excavation.
    b. Soil (regardless of nature) or other debris encountered above proposed subgrade elevations shall be considered general excavation unless determined by the Architect to meet the definition of rock.
    c. In-place densification by vibratory and static rolling of existing soils at exposed subgrades, as described herein, shall be considered General Excavation.

2. Unsuitable Soil Excavation: Removal and disposal of soil materials or other debris encountered below proposed subgrade elevations which is deemed unsuitable to remain in place by the Architect or Owner's Independent Testing Agency.

    a. Soil and/or other debris encountered above proposed subgrade elevations shall be considered general excavation.
    b. Soil material which, in the opinion of the Architect or Owner's independent testing agency, can be repaired by scarifying, drying and recompacting or material which is made unsuitable by delay of work, lack of protection or other actions of the Contractor or his Sub-Contractors shall not be considered as unsuitable soil and shall be repaired or replaced by the Contractor at no additional cost to the Owner. Moisture content alone shall not be the determining factor as to the presence of unsuitable soil.
    c. Any material moved or removed without the measurement by the Owner's independent testing agency and approval by the Architect will be considered as general excavation.
    d. Surface topsoil, regardless of thickness encountered, shall not be considered unsuitable soil.
    e. Stones, rocks and boulders not meeting classifications of rock shall not be considered unsuitable soil. Stones, rocks and boulders shall be removed from soil as necessary if soil is to be used as fill or backfill. Removed stones, rocks and boulders shall be removed from the site.
    f. The unsuitable soil allowances shall be for unsuitable soils only and not for repair of weather related deterioration of subgrade. These Allowances are not for required on-site cut and off-site fill necessary to bring subgrades and grades to elevations shown on drawings. Contractor shall be responsible for proper drying and dewatering procedures, as necessary, as part of his normal operations.

3. Mass rock Excavation: Removal, in Open Excavations, of rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1.5-cu.yd. that cannot be removed by rock excavating equipment equivalent to the following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted. In the event rock (as defined above) is encountered, the Contractor shall immediately notify the Architect.

    a. Mass Rock Excavation Equipment: Late-model, track-type CAT D-8 crawler tractor operating at one mile per hour in the lowest available gear, and at the highest normal operating rpm pulling a sharp, single-toothed ripper. The Contractor shall provide equipment specification and test data verifying that the equipment to be used for demonstration purposes complies with the minimum requirements. The equipment shall be

in good repair and in proper working condition. The Owner reserves the right to inspect and approve the equipment to be used for demonstration purposes. The Contractor shall demonstrate (at no additional cost) to the Architect or Owner's independent testing agency that the rock cannot be practically ripped with equipment equivalent that specified above without systematic drilling and blasting. Mass rock is defined as material which, after 1 hour of continuous ripping using the equipment described above, produces less than 30 cubic yards of removable material.

4. Trench Rock Excavation: Removal, in Trench Excavations, of rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1.0-cu.yd. that cannot be removed by rock excavating equipment equivalent to the following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted. In the event rock (as defined above) is encountered, the Contractor shall immediately notify the Architect.

    a. Trench rock excavation equipment: Late-model, track mounted CAT 330 or equivalent hydraulic excavator equipped with a narrow (36" max) bucket with new rock teeth and operating at the highest normal operating RPM. The Contractor shall provide equipment specification and test data verifying that the equipment to be used for demonstration purposes complies with the minimum requirements. The equipment shall be in good repair and in proper working condition. The Owner reserves the right to inspect and approve the equipment to be used for demonstration purposes. Trench rock is defined as material which, after 1 hour of continuous digging using the equipment described above, removes less than 10 cubic yards of material.

5. Classified excavation requirements:

    a. Excavations more than both 10 feet in width and more than 30 feet in length are defined as Open Excavations. Excavations less than both 30 feet in width and less than 30 feet in length are defined as Trench Excavations.
    b. Contractor shall expose and clean the rock material for inspection and measurement by the Architect.
    c. Do not excavate rock or unsuitable soil until it has been classified and cross-sectioned by the Owner's independent testing agency or Architect. Any material moved or removed without the measurement by the Owner's independent testing agency and approval by the Architect will be considered as General Excavation.
    d. The Architect shall be the final judge on what is classified as unsuitable or rock excavation.
    e. The contractor may be required to provide equipment specification data verifying that the above minimum-rated equipment will be used for demonstration purposes. The equipment shall be in good repair and in proper working condition.
    f. Rippable rock, weathered rock or overburden which is not classified as rock according to the above definitions shall be considered General Excavation.

1.6 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.

B. Test Reports: In addition to test reports required under field quality control, submit the following:

1. Laboratory analysis of each soil material proposed for fill and backfill from on-site and borrow sources.
2. One optimum moisture-maximum density curve for each soil material.

3. Reports of all laboratory and field tests including evaluations of subgrades and foundation bearing conditions.
4. As-built survey of athletic fields, courts and tracks demonstrating compliance with specified tolerances.
5. Reports of Special Inspections.

C. Report of rock or unsuitable soil removal with quantities confirmed in writing by the Architect or Owner's independent testing agency.

1.7 QUALITY ASSURANCE

A. Codes and Standards: Perform earthwork complying with requirements of authorities having jurisdiction. Any earthwork required for preparation of parking areas and drives shall comply with current NCDOT Standard Specifications as per the North Carolina Construction Manual.

B. Comply with applicable requirements of NFPA 495--Explosive Materials Code.

C. Testing and Inspection Service: Owner will employ a qualified independent geotechnical engineering testing agency to classify proposed on-site and borrow soils to verify that soils comply with specified requirements and to perform required field and laboratory testing.

D. Special Inspections: Owner will employ a qualified Special Inspector or Special Inspection Agency to perform verification and inspection of earthwork construction in accordance with NC State Building Code.

E. Preinstallation Conference: Conduct conference at Project site to comply with requirements of Division 1

1. Before commencing earthwork, meet with representatives of the governing authorities, Owner, Architect, consultants, Geotechnical Engineer, independent testing agency, and other concerned entities. Review earthwork procedures and responsibilities including testing and inspection procedures and requirements. Notify participants at least 3 working days prior to convening conference. Record discussions and agreements and furnish a copy to each participant.

1.8 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt existing utilities serving facilities occupied by the Owner or others except when permitted in writing by the Architect and then only after acceptable temporary utility services have been provided.

1. Provide a minimum 48-hours' notice to the Architect and receive written notice to proceed before interrupting any utility.

B. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shutoff services if lines are active.

1.9 PAYMENT

A. General Excavation: All general excavation to the lines and grades indicated on the drawings including all necessary off-site disposal of excess materials and/or off-site borrow of fill materials shall be included in the base bid.

1. No statement is made or implied that the on-site grading and earthwork indicated on the drawings is balanced.

B. Unsuitable Soil Material Excavation: Unsuitable soil material excavation will be paid by unit prices included in the Contract Documents.

1. Unused amounts of monies included under allowances shall be credited to the Owner by deduct change order.

C. Rock Excavation: Mass rock and Trench rock excavation will be paid by unit prices included in the Contract Documents.

1. Unused amounts of monies included under allowances shall be credited to the Owner by deduct change order.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide approved borrow soil materials from off-site when sufficient approved soil materials are not available from excavations.

B. Satisfactory Soil Materials: ASTM D 2487 soil classification groups GW, GC, GP, GM, ML, CL, SW, SP, SC, and SM; free of rock or gravel larger than 2 inches (50 mm) in any dimension, debris, waste, frozen materials, vegetation and other deleterious matter. Additionally, satisfactory soil for use as fill in Structural Areas shall meet the following:

1. SC, SM and SP.
2. Sand with less than 12% fines (silt and clay) shall not be used without adequate drainage installed as it may create perched water tables.

C. Unsatisfactory Soil Materials: ASTM D 2487 soil classification groups MH, CH, OL, OH, and PT. Soils having a Plasticity Index greater than 20 and a Liquid Limit greater than 50 are also unsatisfactory within structural (pavement and building) areas except if placed as specified above.

D. Unsuitable Soil: Refer to paragraph 1.5 of this Section.

E. Backfill and Fill Materials: Satisfactory soil materials.

F. Impervious Fill & Clay Liner (at Stormwater Control Measures): Clayey or silty soil mixtures capable of compacting to a dense state with a maximum permeability of 0.01-in/hr and compacted to at least 95% of the maximum dry density per ASTM D-698. ASTM D 2487 soil classification groups CH, CL, SC, MH, and ML; free of rock, brush, roots, and other organic material subject to decomposition.

2.2 PROCESSED AGGREGATE MATERIALS

A. Base Course Material: Type A aggregate base course meeting the requirements of Section 520 of NCDOT “Standard Specifications for Roads and Structures.”

B. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.

C. Bedding Material: #57 washed stone.

D. Drainage Fill: #57 washed stone.

E. Filtering Material: #57 washed stone.

F. Coarse Sand: Grain Size Distribution (ASTM C136-95A):

Sieve Size	Percent Passing
3/8”	100
#4	95-100
#8	85-97
#16	60-80
#30	10-20
#50	5-15
#100	0-5

2.3 FLOWABLE FILL

A. Flowable fill shall consist of a lean concrete mixture of portland cement, aggregate and water. Water reducing and air-entraining admixtures may be added at the option of the Contractor.

1. Material shall comply with the requirements of Division 03 Section, Cast-in-Place Concrete.
2. The proportions of the mix shall be determined by the Contractor to obtain a compressive strength of 100-300-psi at 28-days.

2.4 ACCESSORIES

A. Drainage (Filter) Fabric: Nonwoven geotextile, specifically manufactured as a drainage geotextile; made from polyolefins, polyesters, or polyamides; and with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:

1. Grab Tensile Strength: 110 lbf (490 N); ASTM D 4632.
2. Tear Strength: 40 lbf (178 N); ASTM D 4533.
3. Puncture Resistance: 50 lbf (222 N); ASTM D 4833.
4. Water Flow Rate: 150 gpm per sq. ft. (100 L/s per sq. m); ASTM D 4491.
5. Apparent Opening Size: No. 50 (0.3 mm); ASTM D 4751.

B. Separation/Stabilization Fabric: Woven geotextile, specifically manufactured for use as a separation and or stabilization geotextile; made from polyolefins, polyesters, or polyamides; and with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:

1. Grab Tensile Strength: 200 lbf (890 N); ASTM D 4632.
2. Tear Strength: 75 lbf (333 N); ASTM D 4533.
3. Puncture Resistance: 90 lbf (400 N); ASTM D 4833.
4. Water Flow Rate: 4 gpm per sq. ft. (2.7 L/s per sq. m); ASTM D 4491.
5. Apparent Opening Size: No. 30 (0.6 mm); ASTM D 4751.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

B. Protect subgrades and foundation soils against freezing temperatures or frost. Provide protective insulating materials as necessary.

C. Provide erosion control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

D. Site Maintenance: The Contractor shall be responsible to take whatever measures are necessary to ensure reasonable accessibility to and on the construction site so that undue delays are avoided under normal weather conditions. These measures shall include, but not be limited to, the following:

1. Maintaining the surface of the soils in a manner to promote drainage runoff and avoid ponding of water, especially prior to predicted rain events.
2. Avoiding operation of temporary water sources or hoses in a manner which will cause unnecessary and repeated wetting of the site.
3. Fill in severely rutted areas which are ponding water during the construction activities or after rain events with drainage fill material to assist drying and allow construction activities to continue.
4. Provide drying of surface soils and soils intended for filling or backfilling as required to promote accelerated drying of those materials.
5. After successful drying efforts or prior to predicted rain events, grade the areas back to a smooth condition to promote drainage runoff.
6. Controlling vehicular traffic, both construction and personal on the site in a manner to prevent undue damage to soils whenever possible and practical.
7. Providing temporary staging areas of crushed stone or other materials around the construction site which will better withstand the weather and traffic and keep the site accessible immediately or shortly after rain events.
8. Provide de-watering equipment for any areas collecting water which may affect construction or soil densities under built areas.
9. Any claims for weather related delays considered shall be considered with particular attention paid to the Contractor's efforts in regard to the above requirements

3.2 DEWATERING

A. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
2. Install a dewatering system to keep subgrades dry and convey groundwater away from excavations. Maintain until dewatering is no longer required.

C. Design, furnish, install, test, operate, monitor, and maintain temporary dewatering systems of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.

1. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls as needed.
2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.
3. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, prevention of flooding in excavation, and prevention of damage to subgrades and permanent structures.
4. Prevent surface water from entering excavations by grading, dikes, or other means.
5. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.
6. Remove dewatering system when no longer required for construction.

D. Soft wet soils, if present at the surface, shall be dried and compacted in place by the Contractor and be stable under proofrolling prior to placing fill. Drying shall be accomplished by discing, plowing or other means necessary and shall be included in the Contractor's bid. Site soils are typical of the area and susceptible to loss of strength if they become wet, resulting in softening and rutting during construction. Site soils are extremely moisture sensitive, therefore, the Contractor shall take active and aggressive steps to dry soil materials wet of optimum to maintain construction progress through the work and to maintain access to and around the construction. The Contractor, at his option and cost may remove unstable, wet materials and replace with available fill materials in lieu of accomplishing soil drying procedures.

3.3 EXPLOSIVES

A. Explosives: Explosives shall not be used.

3.4 STABILITY OF EXCAVATIONS

A. Comply with local codes, ordinances, and requirements of authorities having jurisdiction to maintain stable excavations. Contractor is responsible for ensuring all excavation operations and other construction comply with applicable OSHA requirements. Contractor shall provide temporary shoring and bracing as needed to construct the proposed improvements and comply with the above requirements.

3.5 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. Extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

B. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated cross sections, elevations, and grades.

3.7 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated slopes, lines, depths, and invert elevations.

1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

B. Excavate trenches to uniform widths to provide a working clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches (300 mm) higher than top of pipe or conduit, unless otherwise indicated.

1. Clearance: As indicated

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove stones and sharp objects to avoid point loading.

1. For pipes or conduit less than 6 inches (150 mm) in nominal diameter and flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.

2. For pipes and conduit 6 inches (150 mm) or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe circumference. Fill depressions with tamped sand backfill.
3. Where encountering rock or another unyielding bearing surface, carry trench excavation 6 inches (150 mm) below invert elevation to receive bedding course.

D. Soil excavated from trenches that is to be used as backfill or fill shall be moisture conditioned as needed prior to placement and compaction as backfill or fill.

3.8 IMPROVEMENT AND TESTING OF SUBGRADE PRIOR TO PLACING FILL OR OTHER IMPROVEMENTS

A. Notify Architect or Owner's independent testing agency when excavations have reached required subgrade.

B. After stripping is complete the exposed subgrade shall be densified in place and then proofrolled as specified below.

C. In-Place Densification: Existing subgrade soils shall be densified in-place with a medium weight vibratory roller to improve the support of the exposed subgrade soils.

1. At least three passes shall be made in each orthogonal direction.
2. Vibratory rolling shall be performed during dry weather. If water is brought to the surface during vibratory rolling, discontinue rolling until the water subsides.
3. Static rolling shall be employed within 30-ft of existing structures to reduce the risk of damage caused by vibrations.
4. Allow pore pressures to dissipate for at least 12 hours following completion of vibratory rolling. After waiting period, perform proofrolling of the densified area.
5. The rolling operations shall be observed by the Owner's independent testing agency.

D. Proofrolling: Subgrade soils shall be proofrolled with a fully loaded dual wheel tandem axle dump truck or similar construction equipment. Four passes shall be made in each orthogonal direction. The proofrolling operation shall be observed by the Architect or Owner's independent testing agency. Should any area fail to tighten up after proofrolling and continue to rut and/or pump, the soil shall be scarified and moistened or aerated and recompacted and/or re-densified in-place with a vibratory roller. Repeat proofrolling operations.

E. When Architect or Owner's independent testing agency determines that unforeseen unsuitable soil is present, continue excavation and replace with compacted backfill or fill material as directed.

1. Unforeseen additional excavation and replacement with suitable material approved by the Architect will be considered unsuitable material and will be paid by unit prices included in the Contract Documents. Refer to Division 1 Sections.

F. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect. Install french drains at design subgrade if directed by the Owner's independent testing agency and approved by the Architect.

3.9 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending indicated bottom elevation of concrete foundation or footing to excavation bottom, without altering required top elevation. Lean concrete fill may be used to bring elevations to proper position when acceptable to the Architect.

1. Fill unauthorized excavations under other construction as directed by the Architect or the Owner's independent testing agency.

B. Where indicated widths of utility trenches are exceeded, provide stronger pipe, or special installation procedures, as required by the Architect.

3.10 STORAGE OF SOIL MATERIALS

A. Stockpile excavated materials acceptable for backfill and fill soil materials, including acceptable borrow materials. Stockpile soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent wind-blown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.11 BACKFILL

A. Backfill excavations promptly, but not before completing the following:

1. Acceptance of construction below finish grade including, where applicable, damp-proofing, waterproofing, and perimeter insulation.
2. Surveying locations of underground utilities for record documents.
3. Testing, inspecting, and approval of underground utilities.
4. Concrete formwork removal.
5. Removal of trash and debris from excavation.
6. Removal of temporary shoring and bracing, and sheeting.
7. Installing permanent or temporary horizontal bracing on horizontally supported walls.
8. Removal of objectionable materials, including rocks larger than acceptable size, from backfill soils.

3.12 UTILITY TRENCH BACKFILL

A. Place and compact bedding course on rock and other unyielding bearing surfaces and to fill unauthorized excavations. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

B. Pipe sleeves and concrete backfill trenches that carry below or pass under footings and that are excavated within 18 inches (450 mm) of footings. Place concrete to level of bottom of footings. Contact the Architect or the Owner's independent testing agency to coordinate details, procedures and possible alternatives.

C. Provide 4 inch (100 mm) thick concrete base slab support for piping or conduit less than 30 inches (750 mm) below surface of roadways. After installation and testing, completely encase piping or conduit in a minimum of 4 inches (100 mm) of concrete before backfilling or placing roadway base course.

D. Place and compact initial backfill of satisfactory soil material or base course material, free of particles larger than 1 inch (25 mm), to a height of 12 inches (300 mm) over the utility pipe or conduit.

1. Carefully compact material under pipe haunches and bring backfill evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.
2. Moisture condition soil materials as needed prior to placement as backfill.

E. Coordinate backfilling with utilities testing.

F. Fill voids with approved backfill materials as shoring and bracing, and sheeting is removed.

G. Place and compact final backfill of satisfactory soil material to final subgrade.

1. Moisture condition soil materials as needed prior to placement as backfill.

H. Install detectable warning tape directly above utilities, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.13 FILL

A. Preparation: Remove vegetation, topsoil, debris, wet, frozen, and unsatisfactory soil materials, obstructions, and deleterious materials from ground surface prior to placing fills.

1. Plow, strip or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing surface.

B. Perform in-place densification of subgrade and obtain approval of subgrade as specified prior to placing fill.

C. Obtain approval of fill materials. Remove all objectionable materials, including stones larger than acceptable size, from fill materials.

D. Place fill material in layers to required subgrade elevations for each location listed below.

1. Under grass, use satisfactory excavated or borrow soil material.
2. Under walks, pavements, buildings and other structural areas use base course material, or satisfactory excavated or borrow soil material.
3. In pond embankments, use impervious fill for core/cut-off trench and suitable soil for remainder of embankment.

E. Following placement of fill the subgrade of building and pavement areas shall be proofrolled as described in the Field Quality Control section. The proofrolling operation shall be observed by the Owner's testing agency. Should any area fail to tighten up after proofrolling and continue to rut and/or pump, the soil shall be scarified and moistened or aerated and recompacted. Repeat proofrolling operations.

F. Overbuild Deep Fill Slopes: Fill slopes shall be overbuilt a sufficient distance and then cut back to achieve required compaction at the design slope surface.

3.14 MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
2. Remove and replace or scarify and air-dry satisfactory soil material that is too wet to compact to specified density.

a. Stockpile or spread and dry removed wet satisfactory soil material.

3.15 COMPACTION

A. Place backfill and fill materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches (100 mm) in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill materials evenly on all sides of structures to required elevations. Place backfill and fill uniformly along the full length of each structure.

C. Percentage of Maximum Dry Density Requirements: Compact soil to not less than the following percentages of maximum dry density according to ASTM D698 Standard Proctor:

1. Under structures, steps, walks, and pavements:
    a. Compact each layer of backfill or fill material at 95% of the standard Proctor Density (ASTM D-698).
    b. Compact each layer of the final 12-in of backfill material in building and pavement areas at 98% of the standard Proctor Density (ASTM D-698).
    c. Moisture content of the fill during placement shall be kept within +/-2% of optimum.
    d. Under pavements within NCDOT rights-of-way or new pavement to be constructed to NCDOT standards compact the top 8 inches below pavement subgrade to at least 100% density in accordance with AASHTO T-99 as modified by NCDOT.
2. Under lawn or unpaved areas, compact the top 6 inches below subgrade and each layer of backfill or fill material at 90 percent maximum dry density.
3. In pond embankments, compact each layer of backfill or fill material at 95% of the standard Proctor Density (ASTM D-698). Moisture content of the fill during placement shall be kept within 0% to +3% of optimum.
4. Compact each layer of aggregate base material under pavement to 100% density in accordance with AASHTO T-180 as modified by NCDOT or to at least 98% of the nuclear target density as specified in section 520 of the NCDOT Standard Specifications for Roads and Structures.

3.16 GRADING

A. General: Uniformly grade areas to a smooth surface, free from irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between existing adjacent grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to conform to required surface tolerances.

B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Lawn or Unpaved Areas: Plus or minus 1.2 inches (0.10 foot).
2. Walks: Plus or minus 1.2 inches (0.10 foot).
3. Pavements: Plus or minus 1/2 inch (0.05 foot).
4. Athletic/Play Fields:
    a. Subgrade: Plus or minus 1.2 inches (0.10 foot).
    b. Final Grade (Topsoil): Plus or minus 1/2 inch (0.05 foot) when tested with a 10 foot straightedge.

C. Lawn & Play/Athletic Field Fine Grading: Finish grade lawn and field areas to a smooth, even surface with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit fine grading to areas that can be planted in the immediate future. Remove trash, debris, stones larger than 1/2 inch in any dimension, and other objects that may interfere with planting or maintenance operations. Remove all glass, wire or other objects of any size which may cause injury. Surfaces shall be top dressed with sterile sand following establishment of grass as necessary to obtain smooth, consistent surface.

3.17 SUBSURFACE / FOUNDATION DRAINAGE

A. Drainage Piping: Drainage pipe is specified in Division 33 Section "Site Storm Drainage Utilities."

B. Subsurface Drain: Place a layer of drainage fabric around perimeter of drainage trench as indicated. Place a course of drainage fill material on drainage fabric to support drainage pipe. Encase drainage pipe in drainage fill material and wrap in drainage fabric, overlapping sides and ends at least 6 inches.

1. Compact each course of drainage fill material.
2. Place satisfactory excavated or borrow soil material or topsoil fill material (as appropriate) over drain to final grade.

3.18 BASE COURSES

A. Under pavements, walks, courts and tracks, place base course material on prepared subgrades.

1. Where indicated, place biaxial geogrid directly on prepared subgrade under all asphalt and concrete pavement without wrinkles or folds. Seems shall be overlapped a minimum of 12-in. Geogrid placement shall be observed by the Owner's Independent Testing Agency prior to covering. Place compacted base course over geogrid and control traffic and operation of equipment over geogrid and base course in accordance with manufacturer's instructions.
2. Compact base courses at optimum moisture content to required grades, lines, cross sections and thickness to not less than 100 percent density in accordance with AASHTO T-180 as modified by NCDOT or to at least 98% of the nuclear target density as specified in section 520 of the NCDOT Standard Specifications for Roads and Structures.
3. Shape base course to required crown elevations and cross-slope grades.
4. When thickness of compacted base course is 6 inches or less, place materials in a single layer.
5. When thickness of compacted base course exceeds 6 inches, place materials in equal layers, with no layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick when compacted.
6. Following compaction testing and within 48 hours prior to the application of asphalt or concrete pavement, the aggregate base course shall be proofrolled with a fully loaded dual wheel tandem axle dump truck or similar construction equipment. Four passes shall be made in each orthogonal direction. The proofrolling operation shall be observed by the Architect or Owner's independent testing agency. Should any area fail to tighten up after proofrolling and continue to rut and/or pump, the base course shall be scarified and moistened or aerated and recompacted. Repeat proofroll testing.

B. Pavement Shoulders: Place shoulders along edges of base course to prevent lateral movement. Construct shoulders at least 12 inches (300 mm) wide of acceptable soil materials and compact simultaneously with each base course layer.

3.19 FIELD QUALITY CONTROL

A. Owner's Independent Testing Agency Services: Allow testing agency to evaluate and test each subgrade and each fill or backfill layer. Do not proceed until test results for previously completed work verify compliance with requirements.

1. Perform testing and evaluation of borrow or fill soils for compliance with material specifications of this Section.
2. Perform field in-place density tests according to ASTM D 1556 (sand cone method), ASTM D6938 (nuclear gauge method) or equal as determined by the Owner's independent testing agency.
   a. Structural Areas: At subgrade and at each compacted fill, backfill layer, and aggregate base course layer, perform at least one field in-place density test for every 2,500 sq.ft. or

less of building area and every 5,000 sq.ft. or less of paved area, but in no case fewer than three tests. Observe proofrolling of finished subgrade and aggregate base course.

b. Trench Backfill: Perform at least one field in-place density test per 2 feet of backfill per 100 linear feet or less of trench outside of limits of buildings, but no fewer than two tests per trench per day.

c. Non-Structural Areas: Field density and moisture content tests shall be performed on the fill and backfill at a rate of at least one test per every 15,000 square feet of area being filled.

3. Building Foundation Excavations: Evaluate bearing subgrades with hand augers and Dynamic Cone Penetrometer (DCP) testing.
4. Observe proof-rolling as described herein.
5. Refer to Special Inspections section below for testing within building limits.

B. When testing agency reports that subgrades, fills, or backfills are below specified density, scarify and moisten or aerate, or remove and replace soil to the depth required, recompact and retest until required density is obtained. Contractor shall be responsible for all costs associated with re-testing required due to failed compaction.

C. Proofrolling: Subgrade to receive fill, finish subgrade of building or pavement areas, and aggregate base courses shall be proofrolled with a fully loaded dual wheel tandem axle dump truck or similar construction equipment. Four passes shall be made in each orthogonal direction. The proofrolling operation shall be observed by the Owner's testing agency. Should any area fail to tighten up after proofrolling and continue to rut and/or pump, the soil shall be scarified and moistened or aerated and recompacted. Repeat proofrolling operations.

D. Pond and Wetland Infiltration / Leakage Testing: Following completion of new permanent detention ponds or constructed wetlands, perform wetland/pond infiltration / leakage testing.

1. Following installation of the clay liner, perform wetland/pond infiltration / leakage testing.
2. Ensure the temporary skimmer is still connected to the pond drain. Close the pond drain valve and allow the wetland/pond to fill with water to the permanent pool elevation.
3. Allow the water level in the wetland/pond to equalize through normal drainage or by briefly opening the pond drain valve to bring the water level to 1-3-inches below the permanent pool elevation. Reclose the pond drain valve.
4. Perform the remainder of the testing during a period of no precipitation.
5. Check the interior of the outlet structure for visible leakage and repair as needed.
6. Attach a vertical yardstick to the side of the riser extending above and below the water level for water level monitoring.
7. Record the water level reading on the yardstick with date and time stamped photo.
8. Record the water level reading again at 24-hrs and 48-hrs after the original reading.
9. Provide the photo records to the Engineer for analysis.
10. Await approval before proceeding with further wetland/pond construction.

3.20 SPECIAL INSPECTIONS

A. Allow Special Inspections and tests to be performed by the Special Inspector or Special Inspection Agency.

A. Verification and inspection of earthwork construction shall be in accordance with the applicable sections of the current North Carolina State Building Code, and as follows:

1. Review laboratory test reports, certificates of compliance, or other data submitted to show compliance with specifications, and conduct field inspections and tests during earthwork operations as necessary to verify compliance with the contract documents.

2. All site stripping and proofrolling operations shall be observed and monitored. Verify suitability of subgrade prior to installation of fill.
3. At footing subgrades, test each soil stratum to verify design bearing capacities. Verification and approval of footing subgrades may be based on a comparison of subgrade with test data. Perform additional testing as necessary.
4. Test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:

    a. 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 building slab, but in no case fewer than three tests.
    b. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 50 feet or less of wall length, but no fewer than two tests.
    c. Trench Backfill in Building Areas: At each compacted initial and final backfill layer, at least one test for every 50 feet or less of trench length, but no fewer than two tests.

B. Allow Special Inspector 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. When 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.

D. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.

E. Additional testing performed to determine compliance of corrected work with specified requirements shall be at Contractor’s expense.

3.21 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and re-establish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace material to depth directed by the Architect or Owner’s independent testing agency; reshape and recompact at optimum moisture content to the required density.

C. Settling: Where settling occurs during the Project correction period, remove finished surfacing, backfill with additional approved material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to the greatest extent possible.

3.22 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off the Owner's property.

END OF SECTION 312000

SECTION 312500 - EROSION & SEDIMENT CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and other Division-1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following: Soil erosion and sedimentation control for all areas of the site that are graded or disturbed by any construction operations and elsewhere as indicated on the Drawings or specified herein. Erosion control shall be as specified herein and as may be required by actual conditions and governing authorities.

B. The Contractor is fully responsible for all applicable permits and approvals for off-site borrow and waste areas.

C. The Contractor shall have full responsibility for the construction and maintenance of erosion control and sedimentation control facilities as shown on the Drawings and as specified herein. The Contractor shall at all times provide the operation and maintenance necessary to operate the permitted sediment and erosion controls at optimum efficiency.

D. The Contractor shall provide permanent or temporary ground cover as soon as possible over disturbed areas of the site, and shall provide permanent or temporary ground cover in no more than 14 days after construction activities have permanently or temporarily ceased over the disturbed area. Temporary or permanent ground cover shall be provided on slopes within 7 days after construction activities have permanently or temporarily ceased.

E. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 31 Section "Site Clearing"
2. Division 31 Section "Earth Moving"
3. Division 32 Section "Planting"

1.3 PRODUCT HANDLING

A. Deliver seed, fertilizer and other packaged materials in unopened original packages with labels legible and intact. Seed packages shall bear a guaranteed analysis by a recognized authority.

B. On-site storage of materials shall be kept to a minimum. Wet or damaged seed or other material shall be removed from the project site immediately.

1.4 MONITORING AND RECORD KEEPING

A. Contractor shall abide by all conditions of the General Permit to Discharge Stormwater under the National Pollutant Discharge Elimination System (NPDES), Permit No. NCG010000 (obtain copy from Owner) and the general requirements listed below. NPDES General Permit No. NCG01000 can be viewed at:
https://files.nc.gov/ncdeq/Energy%20Mineral%20and%20Land%20Resources/Stormwater/NCG010000_Final_Permit_2019_04_01.pdf

B. All sediment and erosion control devices and facilities shall be inspected at least once every seven (7) calendar days and within 24 hours after any storm event of greater than 0.5 inches of rain per 24 hour period.

C. Stormwater discharges shall be inspected by observation for stormwater discharge characteristics (as listed below) at the above frequency to evaluate the effectiveness of the sediment control facilities, devices or practices. Observations shall be made at all stormwater discharge outfalls and other locations were concentrated stormwater discharges from the site. Observations shall be qualitative, no analytical testing or sampling is required. If any visible off-site sedimentation is leaving the site, corrective action shall be taken to reduce the discharge of sediments.

1. Color.
2. Odor.
3. Clarity.
4. Floating solids.
5. Suspended solids.
6. Foam.
7. Oil sheen.
8. Other obvious indicators of stormwater pollution.

D. The contractor shall perform and keep records of the above inspections. Visible sedimentation found off the site shall be recorded with a brief explanation as the measures taken to prevent future releases as well as any measures taken to clean up the sediment that has left the site. This record shall be made available to the Owner, Architect and governmental authorities.

PART 2 - PRODUCTS

2.1 SOIL AMENDMENTS AND SEED

A. Refer to Division 32 Section “Planting”.

2.2 MISCELLANEOUS

A. Gravel for Stone Filters: Washed No. 57 stone or as indicated on the drawings.

B. Silt Fence Fabric: A synthetic filter fabric or a pervious sheet of polypropylene, nylon, polyester, or polyethylene yarn, which is certified by the manufacturer or supplier as conforming to the following requirements.

1. Tensile Strength (Grab): 90 x 90-lbs. min., ASTM D 4632.
2. Permittivity: 0.05-sec^{-1} min., ASTM D 4491.
3. Apparent Opening Size: #30 US Sieve (0.60-mm) max., ASTM D 4751.
4. UV Resistance (500-hrs): 70%, ASTM D 4355.

C. Filter Fabric (for installation under riprap): Woven geotextile fabric, apparent opening size no larger than US Standard Sieve no. 70, min. grab strength of 120-lbs.

D. Polyacrylamide (PAM) Turbidity Control Log: Soil specific tailored, solid form PAM product containing blends of water treatment components and polyacrylamide co-polymer for water clarification (25 NTU max. at outlet of sediment basin) and erosion control. Product shall be designed for site specific soil and water conditions. APS-700 Series Floc Log by Applied Polymer Systems, Inc. or approved equal.

E. Dewatering Silt Bag: Permeable, non-woven geotextile bag manufactured to accept and filter pumped, sediment-laden water from dewatering activities. Silt bag shall be sized as appropriate for the dewatering pump discharge rate and shall be fitted with a fill spout large enough to accommodate the discharge piping of the dewatering pump. Silt bag shall be Dirtbag as manufactured by ACF Environmental, Inc. or approved equal.

F. Compost Filter Sock: Three-dimensional tubular sediment control device comprised of an organic compost filter media contained in a tubular knitted mesh sock.

1. Filter media shall be mature compost that has been certified by the US Composting Council's Seal of Testing Assurance Program and meeting the following specifications.

   a. pH: 5.0 – 8.5.
   b. Moisture Content: < 60%.
   c. Organic Matter: >25%, dry weight.
   d. Particle Size: 99% passing 2-in sieve, 30-50% passing 3/8-in sieve.

2. Filter sock netting shall be 5-mm thick continuous HDPE filament, tubular knitted mesh with 3/8-in openings. Filled sock shall be a minimum of 12-in in diameter.
3. Stakes shall be 2x2-in x 3-ft wooden stakes.

2.3 INLET PROTECTION MEASURES

A. Manufactured Inlet Sediment Control Device: Storm drainage inlet sediment control device shall be manufactured from woven polypropylene geotextile to fit the opening of a catch basin or drop inlet to filter sediment from runoff entering the inlet. The device shall be a High Flow Siltsack as manufactured by ACF Environmental, Inc. or approved equal. Device shall be provided with an integral curb deflector if installed at a catch basin with a vertical opening adjacent to a horizontal grate.

B. Floor Drain / Area Drain Sediment Filter Device: Small size storm drainage inlet sediment control device shall be manufactured from woven polypropylene geotextile to fit into small diameter floor drains to filter sediment from runoff entering the inlet. The device shall be a Round Drain Insert as manufactured by New Pig Corp. or approved equal.

2.4 CHANNEL AND SLOPE MATTING

A. Channel Matting: Erosion Control blankets for installation in channels shall be a machine-produced mat of curled wood fiber (excelsior) or synthetic polypropylene fiber as specified below. The blanket shall be of consistent thickness with the fiber evenly distributed over the entire area of the mat. The blanket shall be covered with a photo degradable plastic netting secured to the fiber mat. Channel liners shall be excelsior mat unless otherwise indicated on the drawings.

1. Excelsior Mat:

   a. Fiber: Curled wood excelsior of 80% six inch or longer fiber length with a consistent width of fibers evenly distributed throughout the mat. Mat shall be smolder resistant with no chemical additives.
   b. Top and Bottom Netting: Photo degradable extruded plastic netting with maximum mesh size of ¾" x ¾".

2. Wire Staples: 16 gauge steel wire, with minimum of 3" top and 6" long legs. 1.75 staples per square yard of matting minimum.

B. Slope Matting: Erosion Control blankets for installation on slopes (not channels) shall be a machine-produced mat of crimped wood fiber and/or other degradable fibers manufactured without nets or threads. Staples or stakes used to secure the mat shall be wood or 100% biodegradable natural material. No nets or metal staples shall be used on any areas other than within channels.

1. Excelsior Mat:

a. Fiber: Net-free, curled wood excelsior of 80% six inch or longer fiber length with a consistent width of fibers evenly distributed throughout the mat. Mat shall be smolder resistant with no chemical additives.

2. Stakes or Staples: Wood or 100% biodegradable natural material with additive to cause breakdown and 100% degradation within 24-36 months after installation.

2.5 RIPRAP

A. Riprap: Provide riprap of the class and quantity indicated on the Drawings. While no specific gradation is required, the various sizes of the stone shall be equally distributed within the required size range. The size of an individual stone shall be determined by measuring its long dimension. Stone shall meet the requirements of the following table for class and size distribution. No more than 5% of the material furnished can be less than the minimum size specified nor no more than 10% of the material can exceed the maximum size specified.

REQUIRED STONE SIZES - INCHES			
CLASS	MINIMUM	MIDRANGE	MAXIMUM
A	2	4	6
B	5	8	12
1	5	10	17
2	9	14	23

PART 3 - EXECUTION

3.1 GENERAL

A. Existing Structures and Facilities

1. Existing structures, facilities, and water courses shall be protected from sedimentation.
2. The Contractor shall be responsible for the construction of necessary measures, and all costs shall be at the expense of the Contractor.
3. Items to be protected from sedimentation deposits shall include, but are not limited to, all downstream property, natural waterways, streams, lakes and ponds, catch basins, drainage ditches, road gutters, and natural buffer zones.
4. Control measures such as the erection of silt fences, barriers, dams, or other structures shall begin prior to any land disturbing activity. Additional measures shall be constructed as required during the construction.
5. All facilities installed shall be maintained continuously during construction until the disturbed areas are stabilized. Contractor shall remove all erosion control measures at the end of the project at his expense unless otherwise directed by the Owner or his representative.
6. Perform monitoring and record keeping as specified in this section.

3.2 PROTECTIVE MEASURES

A. Protective measures shall conform to all State and Local requirements.

B. Construction and maintenance of sediment and erosion control measures shall be in accordance with all applicable laws, codes, ordinances, rules and regulations.

1. Silt Fence: Hog wire or wire mesh fastened to posts as recommended by the Manufacturer and covered with silt fabric.
2. Berms and Diversion Ditches: These shall be graded channels with a supporting ridge on the lower side constructed across a sloping land surface. Diversion ditches and berms shall be planted in vegetative cover as soon as completed.
3. Mulching: Mulching shall be used to prevent erosion and to hold soil and seed in place during the establishment of vegetation.
4. **Matting: Temporary slope and channel matting shall be used for temporary stabilization during the establishment of seeded cover in all grassed ditches, channels, long slopes, and steep banks (6:1 or steeper) and additional areas as indicated on plans**. Matting shall be installed on any area on site as needed to provide temporary stabilization whether or not matting is indicated on the plan. Install as indicated or per manufacturer's instructions. The installation of matting may be waived by the Architect is surface stabilization is obtained by other methods within the appropriate and agreed time frames. If adequate stabilization is not obtained, the Contractor shall install matting where required at no additional cost to the Owner.
5. Build Berm, Pits and Gravel Filter as shown on Drawings. Maintain during construction to keep erosion and sedimentation to a minimum. When it is necessary to remove berm, pits, and gravel, return area to required profiles and condition.
6. Construction Entrances: Construct all entrances in accordance with plans. Maintain all ingress/egress points to prevent tracking of soil onto the Owner's, public or private roads. Any soil that is tracked onto the roads shall be removed immediately.
7. Riprap: Stone shall be graded so that the smaller stones are uniformly distributed throughout the mass. Stone may be placed by mechanical methods, augmented by hand placing where necessary, provided that when the riprap is completed it forms a properly graded, dense, neat layer of stone.
8. Manufactured Inlet Sediment Control Device: Install device in accordance with manufacturer's instructions and install a curb deflector if appropriate. Inspect device after each rain event and at intervals not exceeding two weeks during construction. Remove, empty, clean, and replace the device as needed during construction. Empty collected sediment in approved, protected location. Remove and dispose of device following full and permanent stabilization of the contributing drainage area.
9. PAM Turbidity Logs: At a minimum, install logs in drainage structures located immediately upstream of sediment basins and traps. Install additional logs in any other locations indicated on the drawings. Install per manufacturer's instructions. Check logs regularly and after every runoff producing rainfall and replace as needed throughout the duration of construction.
10. Dewatering Silt Bag: Install silt bag on an undisturbed slope so incoming water flows downhill through the bag without causing erosion. Remove and replace silt bag when device no longer drains efficiently due to accumulated sediment in bag. Empty bag within disturbed limits of the site protected by other sediment control measures.
11. Compost Filter Logs: Stake filter log every 10-ft. Drive stakes through the center of the log and 1-ft into the ground. If sock netting must be joined, fit beginning of the new sock over the end of the old sock, overlapping by 1-2 ft. Fill with compost and stake the joint.
12. Other Measures: Other methods of protecting existing structures and facilities, such as vegetative filter strips, diversions, rip-rap, baffle boards, and ditch checks used for reduction of sediment movement and erosion, may be used at the option of the Contractor when approved by the appropriate State or local authorities.

C. Provide the following, at a minimum, to prevent windblown dust.

1. Apply straw mulch and establish temporary or permanent ground cover on exposed soil where work is not being actively performed.

2. Cover or establish vegetative cover on stockpiles.
3. Apply water or other approved dust suppressant as needed to soil surfaces before they become excessively dry.
4. Sweep and collect soil that has been tracked onto paved surfaces.

3.3 STABILIZATION

A. Permanently protect stabilized areas prior to the removal of protective devices.

B. After the final establishment of permanent stabilization, remove temporary sediment control measures. Re-spread accumulated sediments as specified.

C. Permanently stabilize all areas disturbed by the removal and re-spreading operations immediately.

3.4 TEMPORARY SEEDING

A. In accordance with the schedule as detailed on the drawings.

3.5 PERMANENT SEEDING

A. In accordance with the schedule as detailed on the drawings.

3.6 MULCHING AND MATTING

A. Apply mulch or matting to retain soil and grass.

B. Mulch areas with slope greater than 5% by spreading a light cover of mulch over seeded area at the rate of not less than 85 lbs. per 1000 sq. ft.

C. Install temporary matting in all grassed ditches, channels, long slopes, and steep banks (6:1 or steeper) and additional areas indicated on plans or where extra protection from erosion is needed.

END OF SECTION 312500

SECTION 313116 - TERMITE CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Soil treatment.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components, and profiles for termite control products.
2. Include the EPA-Registered Label for termiticide products.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Product Certificates: For each type of termite control product.

C. Soil Treatment Application Report: After application of termiticide is completed, submit report for Owner's records and include the following:

1. Date and time of application.
2. Moisture content of soil before application.
3. Termiticide brand name and manufacturer.
4. Quantity of undiluted termiticide used.
5. Dilutions, methods, volumes used, and rates of application.
6. Areas of application.
7. Water source for application.

D. Sample Warranties: For special warranties.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A specialist who is licensed according to regulations of authorities having jurisdiction to apply termite control treatment and products in jurisdiction where Project is located and who employs workers trained and approved by manufacturer to install manufacturer's products.

1.6 FIELD CONDITIONS

A. Soil Treatment:

1. Environmental Limitations: To ensure penetration, do not treat soil that is water saturated or frozen. Do not treat soil while precipitation is occurring. Comply with requirements of the EPA-Registered Label and requirements of authorities having jurisdiction.
2. Related Work: Coordinate soil treatment application with excavating, filling, grading, and concreting operations. Treat soil under footings, grade beams, and ground-supported slabs before construction.

1.7 WARRANTY

A. Soil Treatment Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work consisting of applied soil termiticide treatment will prevent infestation of subterranean termites. If subterranean termite activity or damage is discovered during warranty period, re-treat soil and repair or replace damage caused by termite infestation.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain termite control products from single source from single manufacturer.

2.2 SOIL TREATMENT

A. Termiticide: EPA-Registered termiticide acceptable to authorities having jurisdiction, in an aqueous solution formulated to prevent termite infestation.

≥
1. Premise 75.
2. Talstar Professional Insecticide
3. Termidor 80 WG.

B. Service Life of Treatment: Soil treatment termiticide that is effective for not less than five years against infestation of subterranean termites.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for moisture content of soil per termiticide label, interfaces with earthwork, slab and foundation work, landscaping, utility installation, and other conditions affecting performance of termite control.

B. Proceed with application only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. General: Prepare work areas according to the requirements of authorities having jurisdiction and according to manufacturer's written instructions before beginning application and installation of termite control treatment(s). Remove extraneous sources of wood cellulose and other edible materials, such as wood debris, tree stumps and roots, stakes, formwork, and construction waste wood from soil within and around foundations.

B. Soil Treatment Preparation: Remove foreign matter and impermeable soil materials that could decrease treatment effectiveness on areas to be treated. Loosen, rake, and level soil to be treated, except previously compacted areas under slabs and footings. Termiticides may be applied before placing compacted fill under slabs if recommended in writing by termiticide manufacturer.

1. Fit filling hose connected to water source at the site with a backflow preventer, according to requirements of authorities having jurisdiction.

3.3 APPLYING SOIL TREATMENT

A. Application: Mix soil treatment termiticide solution to a uniform consistency. Distribute treatment uniformly. Apply treatment at the product's EPA-Registered Label volume and rate for maximum specified concentration of termiticide to the following so that a continuous horizontal and vertical termiticidal barrier or treated zone is established around and under building construction.

1. Slabs-on-Grade: Under ground-supported slab construction, including footings, building slabs, and attached slabs as an overall treatment. Treat soil materials before concrete footings and slabs are placed.
2. Foundations: Soil adjacent to and along the entire inside perimeter of foundation walls; along both sides of interior partition walls; around plumbing pipes and electric conduit penetrating the slab; around interior column footers, piers, and chimney bases; and along the entire outside perimeter, from grade to bottom of footing.
3. Masonry: Treat voids.
4. Penetrations: At expansion joints, control joints, and areas where slabs and below-grade walls will be penetrated.

B. Post warning signs in areas of application.

C. Reapply soil treatment solution to areas disturbed by subsequent excavation, grading, landscaping, or other construction activities following application.

D. Contractor shall notify WCPSS Environmental Health & Safety Department (919-856-8031) a minimum of seven days prior to treating soil to coordinate witnessing of soil treatment.

E. After application, the Contractor shall request soil samples be taken by the North Carolina Department of Agriculture Structural Pest Control Division (919-733-6100). The pesticide recovery level must meet their minimum requirements prior to proceeding with construction.

3.4 PROTECTION

A. Avoid disturbance of treated soil after application. Keep off treated areas until completely dry.

B. Protect termiticide solution dispersed in treated soils and fills from being diluted by exposure to water spillage or weather until ground-supported slabs are installed. Use waterproof barrier according to EPA-Registered Label instructions.

END OF SECTION 313116

SECTION 321216 - ASPHALT PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes provisions for hot-mixed asphalt paving over prepared subbase.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Material Certificates signed by material producer and Contractor, certifying that each material item complies with or exceeds specified requirements of NCDOT "Standard Specifications for Roads and Structures".

C. Job Mix Formula: Provide Geotechnical consultant with two copies of the proposed job mix formula at least ten days prior to beginning work. This formula shall be approved by NCDOT for the type of pavement specified.

D. Recycled Content: 15% minimum, or as approved by NCDOT except as noted below.

1.4 SITE CONDITIONS

A. Weather Limitations for Tack Coats: Apply prime and tack coats only when the surface to be treated is dry and when the atmospheric temperature measured at the location of paving operations away from artificial heat are in compliance with current NCDOT Standard Specifications for Roads and Structures. Do not apply tack coat when weather is foggy or rainy.

B. Weather Limitations for Asphalt Courses: Apply hot-mixed asphalt surface, intermediate and base courses when surface and air temperatures are in compliance with current NCDOT Standard Specifications for Roads and Structures and when base is dry.

C. Grade Control: Establish and maintain required lines and elevations.

D. Traffic Control: Provide traffic control devices, lane closures, positive protection and/or any other warning or positive protection devices necessary for the safety of road users and pedestrians during construction.

1. Traffic control shall be performed in conformance with the latest NCDOT Roadway Standard Drawings and Standard Specifications for Roads and Structures and the Manual on Uniform Traffic Control Devices for Streets and Highways.
2. Sidewalk closures shall be installed as necessary. Pedestrian traffic shall be detoured around these closures and shall be signed appropriately and in accordance with ADA guidelines.
3. Two-way traffic shall be maintained at all times through use of flagmen when necessary.
4. Maintain access for fire-fighting equipment and access to fire hydrants.

1.5 QUALITY ASSURANCE

A. All materials, construction methods and testing shall comply with the requirements of the latest editions of the North Carolina Department of Transportation (NCDOT) “Standard Specifications for Roads and Structures” and the Asphalt Handbook Manual Series No. 4 (MS-4).

B. All work within any NCDOT right-of-way shall conform to the provisions and conditions of the NCDOT encroachment agreement(s) and driveway permit(s) and other applicable NCDOT standards and policies. The encroachment agreement(s) and driveway permit(s) are considered part of the project specifications by reference. Copies of the agreement(s) and permit(s) will be provided upon request from the Architect.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Use locally available materials and gradations that comply with the requirements of the NCDOT "Standard Specifications for Roads and Structures" and exhibit a satisfactory record of previous installations.

B. Aggregate Base Course (ABC): Type A aggregate base course meeting the requirements of the latest version of NCDOT "Standard Specifications for Roads and Structures.”

C. Superpave Asphalt Paving Mix: Superpave base, intermediate and surface asphalt paving mix meeting the requirements of the latest version of NCDOT “Standard Specifications for Roads and Structures.” Types as indicated on the drawings.

D. Tack Coat: Asphalt material meeting the requirement of the latest version of NCDOT "Standard Specifications for Roads and Structures.”

E. Parking Lot Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, Type II, with drying time of less than 45 minutes.

1. Color: White for parking and bus lot striping.
2. Color: Yellow for fire lanes and service area striping.

F. Roadway Pavement Marking Paint: Thermoplastic Alkyd/Maleic and Hydrocarbon type, meeting the requirements of Section 1087 of NCDOT "Standard Specifications for Roads and Structures.”

1. Color: As indicated on the drawings.

PART 3 - EXECUTION

3.1 SURFACE PREPARATION

A. General: Remove loose material from compacted subbase surface immediately before applying base courses of asphalt.

B. Proof-roll prepared subgrade surface as described in Section “Earth Moving” to check for unstable areas and areas requiring additional compaction.

C. Do not begin paving work until deficient subbase areas have been corrected and are ready to receive paving. Ensure subgrade is graded for proper drainage. Repair as needed to avoid ponding on final pavement surfaces.

D. Cold mill surfaces of existing pavements in locations and to depths as indicated on the drawings and as follows.

1. At edges of existing pavement to be overlaid: Cold mill surfaces of existing pavements to a minimum depth of 1.5-inches at longitudinal terminus of asphalt overlays for a minimum width of 10 feet (extend terminus milling width to 100-ft on public roads) and at horizontal terminus (including along gutter line of existing curbs adjacent to asphalt overlays) for a minimum width of 6 feet to allow a smooth transition from full-depth thickness of overlay course to existing pavement or gutter surface. Thoroughly remove all loose material from milled surface before placing tack coat.
2. At pavement to be wedge overlaid: Cold mill surfaces of existing pavements to required depths at edges of asphalt wedge sections on public roads for widths needed to allow minimum depth thickness of wedge course. Thoroughly remove all loose material from milled surface before placing tack coat.
3. At butt joint of new asphalt to existing asphalt: Cold mill surfaces of existing pavements to a minimum depth of 1.5-inches for a minimum width of 12-inches along length of new joint to allow new asphalt surface to be keyed-in to the existing pavement. Thoroughly remove all loose material from milled surface before placing tack coat.

E. Thoroughly remove all dust and loose material from surfaces of that which the tack coat is to be applied along with adjacent surfaces before placing tack coat.

F. Apply tack coat to all contact surfaces of milled asphalt, existing asphalt to be overlaid, and surfaces abutting or projecting into hot-mixed asphalt pavement including the vertical face of adjacent concrete gutter. Distribute evenly and thoroughly at a rate of 0.04 to 0.08 gallons per sq. yd. of surface.

1. Apply only as much tack coat as can be covered during the same day's operation.
2. Take necessary precautions to limit the tracking and/or accumulation of tack coat material on either existing or newly constructed pavements. Excessive accumulation of tack may require corrective measures.
3. Apply tack coat material with a distributor spray bar that can be adjusted to uniformly coat the entire surface at the directed rate. Use hand hose attachments only on irregular area and areas inaccessible to the spray bar. Cover these areas uniformly and completely.
4. Apply tack coat to contact surfaces of gutters, concrete pavements, manholes, vertical faces of old pavements, and all exposed transverse and longitudinal edges of each course before mixture is placed adjacent to such surfaces.
5. Cover curbs, adjacent concrete, and all other appurtenances to protect them from tracking or splattering tack coat material.
6. Do not place any asphalt mixture until the tack coat has sufficiently cured.

G. Allow to dry until at proper condition to receive paving.

H. Exercise care in applying bituminous materials to avoid smearing of adjoining concrete surfaces. Remove and clean damaged surfaces.

I. Place aggregate base courses as specified in Section "Earth Moving".

3.2 PLACING MIX

A. Limitations: Do not produce or place asphalt mixtures during rainy weather, when the subgrade or base course is frozen, or when the moisture on the surface to be paved would prevent proper bond. Comply with all NCDOT weather and temperature limitations.

B. General: Place hot-mixed asphalt mixture on prepared surface, spread, and strike off. Spread mixture at minimum temperature of 225 deg F. Place areas inaccessible to equipment by hand. Place each course to required grade, cross-section, and compacted thickness.

C. Paver Placing: Place in strips not less than 10 feet wide, unless otherwise acceptable to Architect. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Complete base course for a section before placing surface course.

D. Immediately correct surface irregularities in finish course behind paver. Remove excess material forming high spots with shovel or lute.

E. Joints: Make joints between old and new pavements, or between successive days' work, to ensure continuous bond between adjoining work. Construct joints to have same texture, density, and smoothness as other sections of hot-mixed asphalt course. Clean contact surfaces and apply tack coat.

3.3 ROLLING

A. General: Begin rolling when mixture will bear roller weight without excessive displacement.

B. Compact mixture with hot hand tampers or vibrating plate compactors in areas inaccessible to rollers.

C. Breakdown Rolling: Accomplish breakdown or initial rolling immediately following rolling of joints and outside edge. Check surface after breakdown rolling and repair displaced areas by loosening and filling, if required, with hot material.

D. Second Rolling: Follow breakdown rolling as soon as possible, while mixture is hot. Continue second rolling until mixture has been evenly compacted.

E. Finish Rolling: Perform finish rolling while mixture is still warm enough for removal of roller marks. Continue rolling until roller marks are eliminated and course has attained required density. Compact the asphalt to at least the minimum percentage of the maximum specific gravity listed below unless otherwise allowed by NCDOT.

1. SF-9.5A: 90.0% of Maximum Specific Gravity
2. S-9.5B/C, I-19.0B/C, B-25.0B/C: 92.0% of Maximum Specific Gravity.

F. Patching: Remove and replace paving areas mixed with foreign materials and defective areas. Cut out such areas and fill with fresh, hot hot-mixed asphalt. Compact by rolling to specified surface density and smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.4 TRAFFIC MARKINGS

A. Cleaning: Sweep and clean surface to eliminate loose material and dust.

B. Materials: Use thermoplastic marking for permanent markings on public streets and stop bars and crosswalks on private drives and parking lots. Use marking paint for parking and fire lane striping and other markings on private drives and parking lots.

C. Apply traffic paint with mechanical equipment to produce uniform straight edges. Apply at manufacturer's recommended rates to provide minimum 12 to 15 mils dry thickness.

D. Apply thermoplastic markings using application equipment constructed to assure continuous uniformity in the thickness and width of the thermoplastic pavement marking. Use equipment that provides multiple width settings ranging from 4 inches to 12 inches and multiple thickness settings to achieve the pavement marking thickness ranging from 0.090 inch to 0.120 inch. Comply with all applicable NCDOT standards.

E. Remove existing markings as indicated by water blasting.

3.6 FIELD QUALITY CONTROL

A. General: Testing of asphalt concrete mix and in-place hot-mixed asphalt courses for compliance with requirements for thickness and surface smoothness will be done by Owner's testing laboratory in accordance with Division 1 Section “Quality Control.” Repair or remove and replace unacceptable paving as directed by Architect.

1. Owner’s Independent Testing Agency will conduct and interpret tests and state in each report whether tested work complies with or deviates from the specified requirements.

B. Thickness: In-place compacted thickness of each layer of asphalt shall be tested in accordance with ASTM D 3549. Results shall be considered unacceptable if the compacted thickness of any one core sample is greater than 1/2-inch below the thickness specified on the drawings or if the average thickness of all core samples is less that the thickness specified on the drawings.

C. Surface Smoothness: Test finished surface of each hot-mixed asphalt course for smoothness, using 10 feet straightedge applied parallel with and at right angles to centerline of paved area. Surfaces will not be acceptable if exceeding the following tolerances for smoothness:

1. Base Course Surface: 1/4 inch.
2. Wearing Course Surface: 3/16 inch.
3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

D. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979 or AASHTO T 168.

1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.

2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.

a. One core sample will be taken for every 1000 sq. yd. or less of installed pavement, with no fewer than 3 cores taken.
b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.

E. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

F. Contractor shall repair all test core holes with full depth asphalt patch.

G. Perform ponding water tests. Repair areas of pavement that pond water.

H. Check surface areas at intervals as directed by Architect.

END OF SECTION 321216

SECTION 321313 - CONCRETE PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes exterior portland cement concrete paving for the following:

1. Curbs and gutters, pavement, walkways, service court, dumpster pads.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 31 Section "Earth Moving" for subgrade preparation, grading and subbase course.
2. Division 03 Section "Cast-in-Place Concrete" for general building applications of concrete.
3. Division 07 Section "Sealants and Caulking" for joint fillers and sealants within concrete paving and at joints with adjacent construction.

1.3 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 01 Specification Sections.

B. Product data for proprietary materials and items, including reinforcement and forming accessories, admixtures, joint systems, curing compounds, dry-shake finish materials, and others if requested by Architect.

C. Design mixes for each class of concrete. Include percentage of recycled content (20% minimum). Include revised mix proportions when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

D. Scaled plan of proposed construction, expansion and control joint locations in concrete pavement and concrete sidewalk. Submittal of plans for joints in curb and gutter or longitudinal sidewalk 6-feet or less in width is not required.

1.4 QUALITY ASSURANCE

A. Concrete Standards: Comply with provisions of the following standards, except where more stringent requirements are indicated.

1. American Concrete Institute (ACI) 301, "Specifications for Structural Concrete for Buildings."
2. ACI 318, "Building Code Requirements for Reinforced Concrete."
3. ACI 330R, “Guide for the Design and Construction of Concrete Parking Lots.”
4. Concrete Reinforcing Steel Institute (CRSI) "Manual of Standard Practice."

B. Concrete Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.

C. Concrete Testing Service: Engage a qualified independent testing agency to perform materials evaluation tests and to design concrete mixes.

D. All work within any NCDOT right-of-way shall conform to the requirements of the current version of the NCDOT's Policies and Procedures for Accommodating Utilities on Highway Rights of Way, the provisions and conditions of the encroachment agreement(s), and other applicable NCDOT standards and policies. The encroachment agreement(s) are considered part of the project specifications by reference. Copies of the agreement(s) will be provided upon request from the Architect.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.
2. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.

1. Use flexible or curved forms for curves with a radius 100 feet or less.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

2.3 STEEL REINFORCEMENT

A. Plain-Steel Welded Wire Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.

B. Reinforcing Bars: ASTM A 615/A 615M, Grade 60; deformed.

C. Steel Bar Mats: ASTM A 184/A 184M; with ASTM A 615/A 615M, Grade 60, deformed bars; assembled with clips.

D. Plain Steel Wire: ASTM A 82, as drawn.

E. Joint Dowel Bars: Plain steel bars, ASTM A 615/A 615M, Grade 60. Cut bars true to length with ends square and free of burrs.

1. Unless indicated otherwise on the drawings, dowels shall be the following diameter:

a. 6-in slabs: 5/8-in diameter dowels.
b. 7-in slabs: 1-in diameter dowels.
c. 8-in or thicker slabs: 1-1/4-in diameter dowels.

F. Tie Bars: ASTM A 615/A 615M, Grade 60, deformed.

G. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete, and as follows:

1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.

2.4 CONCRETE MATERIALS

A. Cementitious Material: Use one of the following cementitious materials, of the same type, brand, and source throughout the Project:

1. Portland Cement: ASTM C 150, portland cement, Type I, II, or III.

a. Fly Ash: ASTM C 618, Class F. Up to 30% by weight of required cement content, with 1.0-lbs Fly Ash per 1-lb of cement replaced.
b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120 with 1-lb slag per 1-lb of cement replaced.

B. Normal-Weight Aggregates: ASTM C 33, Class 3S coarse aggregate, uniformly graded. Provide aggregates from a single source with documented service record data of at least 10 years' satisfactory service in similar pavement applications and service conditions using similar aggregates and cementitious materials.

1. Maximum Coarse-Aggregate Size: 1-1/2 inches nominal.
2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Water: ASTM C 94/C 94M, potable.

D. Air-Entraining Admixture: ASTM C 260.

E. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

2.5 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry.

B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

C. Water: Potable.

D. Evaporation Retarder: Waterborne, monomolecular film forming; manufactured for application to fresh concrete.

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

2.6 RELATED MATERIALS

A. Expansion and Isolation Joint Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber.

B. Wheel Stops: Precast, air-entrained concrete; 2500-psi minimum compressive strength; approximately 6 inches high, 9 inches wide, and 84 inches long. Provide chamfered corners and drainage slots on underside and provide holes for dowel-anchoring to substrate.

1. Dowels: Galvanized steel, diameter of ¾ inch, minimum length 10 inches.

C. Slip Resistive Aggregate Finish: Factory-graded, packaged, rustproof, non-glazing, abrasive aggregate of fused aluminum-oxide granules or crushed emery aggregate containing not less than 50 percent aluminum oxide and not less than 25 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials.

D. Bonding Agent: ASTM C 1059, Acrylic or styrene butadiene.

E. Epoxy Adhesive: ASTM C 881, two-component material suitable for dry or damp surfaces. Provide material type, grade, and class to suit requirements.

2.7 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete determined by either laboratory trial mixes or field experience.

1. Use a qualified independent testing agency for preparing and reporting proposed concrete mixture designs for the trial batch method.

B. Proportion mixtures to provide normal-weight concrete with the following properties:

1. Compressive Strength (28 Days): 4,500-psi, 4000 psi, 3500 psi, or 3000 psi as indicated on the drawings.
2. Maximum Water-Cementitious Materials Ratio at Point of Placement: As specified by NCDOT Standard Specifications for class of concrete indicated.
3. Slump Limit: Maximum 3.5 inches for non-vibrated, maximum 4 inches for vibrated.

C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:

1. Air Content: 5-1/2 percent plus or minus 1.5 percent for 1-1/2-inch (38-mm) nominal maximum aggregate size.
2. Air Content: 6 percent plus or minus 1.5 percent for 1-inch (25-mm) nominal maximum aggregate size.
3. Air Content: 6 percent plus or minus 1.5 percent for 3/4-inch (19-mm) nominal maximum aggregate size.

D. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

1. Use admixtures in concrete, as required, for placement and workability.

2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

E. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 requirements as follows:

1. Fly Ash: 30 percent.
2. Ground Granulated Blast-Furnace Slag: 50 percent.
3. Combined Fly Ash, and Ground Granulated Blast-Furnace Slag: 50 percent, with fly ash not exceeding 20 percent.

F. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

2.8 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M and ASTM C 1116. Furnish batch certificates for each batch discharged and used in the Work.

1. When air temperature is between 85 deg F and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.

1. For concrete mixes of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
2. For concrete mixes larger than 1 cu. yd., increase mixing time by 15 seconds for each additional 1 cu. yd.
3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

2.9 JOINT SEALANTS

A. Type SL Silicone Sealant for Concrete and Asphalt: Single-component, low modulus, neutral-curing, self-leveling silicone sealant complying with ASTM D 5893 for Type SL.

B. Round Backer Rod for Cold-Applied Sealants: ASTM D 5249, Type 1, of diameter and density required to control sealant depths and pavement bottom-side adhesion of sealant.

2.10 PAVEMENT MARKINGS

A. Parking Lot Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, Type II, with drying time of less than 45 minutes and formulated for concrete surfaces.

1. Color: As indicated on the drawings.

PART 3 - EXECUTION

3.1 SURFACE PREPARATION

A. Proof-roll prepared subbase surface to check for unstable areas and verify need for additional compaction. Do not begin paving work until such conditions have been corrected and are ready to receive paving. Ensure subgrade is graded for proper drainage. Repair as needed to avoid ponding on final pavement surfaces.

B. Remove loose material from compacted subbase surface immediately before placing concrete.

C. Herbicide Treatment: Apply chemical weed control agent in strict compliance with manufacturer's recommended dosages and application instructions. Apply to compacted, dry subbase.

D. Place aggregate base courses as specified in Division 31 Section “Earth Moving”.

3.2 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for paving to required lines, grades, and elevations. Install forms to allow continuous progress of work and so that forms can remain in place at least 24 hours after concrete placement. Set forms to ensure positive drainage and compliance with ADA and Building Code requirements.

B. Check completed formwork and screeds for grade and alignment to following tolerances:

1. Top of Forms: Not more than 1/8 inch in 10 feet.
2. Vertical Face on Longitudinal Axis: Not more than 1/4 inch in 10 feet.

C. Clean forms after each use and coat with form release agent as required to ensure separation from concrete without damage.

3.3 PLACING REINFORCEMENT

A. General: Comply with Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars" for placing and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.

D. Install welded wire fabric in lengths as long as practicable at mid depth of concrete. Lap adjoining pieces at least one full mesh and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

3.4 JOINTS

A. General: Refer to the project plans and details for additional requirements.

1. Construct contraction, construction, and isolation joints true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to the centerline, unless indicated otherwise.
2. When joining existing paving, place transverse joints to align with previously placed joints, unless indicated otherwise.

C. Contraction (Control) Joints: Provide weakened-plane contraction joints, sectioning concrete into areas as indicated below unless shown otherwise on Drawings. Construct contraction joints for a depth equal to at least 1/4 of the concrete thickness, as follows:

1. Tooled Joints: Form contraction joints in fresh concrete by grooving and finishing each edge of joint with a radiused jointer tool.
2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch-wide joints into hardened concrete when cutting action will not tear, abrade, or otherwise damage surface and before development of random contraction cracks.
3. Inserts: Form contraction joints by inserting premolded plastic, hardboard, or fiberboard strips into fresh concrete until top surface of strip is flush with paving surface. Radius each joint edge with a jointer tool. Carefully remove strips or caps of two-piece assemblies after concrete has hardened. Clean groove of loose debris.
4. Spacing:
    a. Concrete Pavement (4-in to 4.5-in thick slabs): Locate contraction joints at 10-ft max. intervals, each way in concrete pavement.
    b. Concrete Pavement (5-in to 5.5-in thick slabs): Locate contraction joints at 12.5-ft max. intervals, each way in concrete pavement.
    c. Concrete Pavement (6-in and greater thick slabs): Locate contraction joints at 15-ft max. intervals, each way in concrete pavement.
    d. Sidewalk & Patios (4-in thick slabs): Locate contraction joints at 5-ft max. intervals, each way in concrete sidewalks/patios unless shown otherwise. Locate contraction joints in sidewalks less than 8-ft in width at 5-ft intervals across the walk. Locate contraction joints in sidewalks of 8-ft and greater width at 5-ft intervals across the walk and equally section the walk lengthwise with joints at 5-ft. max. intervals (example: an 8-ft wide walk shall have contraction joints at 5-ft. spacing across the walk and one joint dividing the walk lengthwise into two, equal 4-ft sections.)
    e. Curbs or Curb & Gutter: Locate contraction joints at 10-ft max. intervals in concrete curbs or concrete curb and gutter.
5. Dowels: Some concrete pavement applications in very heavy load locations require dowels at contraction joints. Refer to the drawings for specific details for such requirements.

C. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than 1/2 hour, unless paving terminates at isolation joints.

1. Continue reinforcement across construction joints unless indicated otherwise. Do not continue reinforcement through sides of strip paving unless indicated.
2. Provide tie bars at sides of paving strips where indicated.
3. Use bonding agent on existing concrete surfaces that will be joined with fresh concrete.

D. Isolation (expansion) Joints: Form isolation joints of preformed joint filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.

1. General spacing: Locate additional expansion joints at the following intervals unless indicated otherwise on the drawings.

    a. Pavement (greater than 4-in thick slabs): None in addition to located specified above.
    b. Sidewalks (4-in thick slabs): 30-ft each way.
    c. Curbs or Curb & Gutter: 90-ft spacing.

2. Extend joint fillers full width and depth of joint 1/2 inch below finished surface where joint sealant is indicated. Place top of joint filler flush with finished concrete surface when no joint sealant is required.

3. Furnish joint fillers in one-piece lengths for full width being placed wherever possible. Where more than one length is required, lace or clip joint filler sections together.
4. Protect top edge of joint filler during concrete placement with a metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

E. Dowel Joints: Install dowel sleeves and dowels or dowel bar and support assemblies at joints where indicated.

1. Use dowel sleeves or lubricate or asphalt-coat one-half of dowel length to prevent concrete bonding to one side of joint.

3.5 CONCRETE PLACEMENT

A. Inspection: Before placing concrete, inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast in. Notify other trades to permit installation of their work. Ensure forms are set to ensure water will not pond on final surface.

B. Remove snow, ice, or frost from base surface and reinforcing before placing concrete. Do not place concrete on surfaces that are frozen.

C. Moisten base to provide a uniform dampened condition at the time concrete is placed. Do not place concrete around manholes or other structures until they are at the required finish elevation and alignment.

D. Comply with requirements and with ACI 304R for measuring, mixing, transporting, and placing concrete.

E. 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.

F. Form and pour concrete pavement with thickened edges along all edges that could be subject to vehicle wheel loads, do not abut a building or wall, or are not doweled to the adjacent pavement or structure.

G. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

H. Consolidate concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping. Use equipment and procedures to consolidate concrete complying with ACI 309R.

1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand-spreading and consolidation. Consolidate with care to prevent dislocating reinforcing, dowels, and joint devices.

I. Screed paved surfaces with a straightedge and strike off. Use bull floats or darbies to form a smooth surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces prior to beginning finishing operations.

J. Place concrete in two operations; strike off initial pour for entire width of placement and to the required depth below finish surface. Lay welded wire fabric or fabricated bar mats immediately in final position. Place top layer of concrete, strike off, and screed.

1. Remove and replace portions of bottom layer of concrete that have been placed more than 15 minutes without being covered by top layer or use bonding agent if acceptable to Architect.

K. Curbs and Gutters: When automatic machine placement is used for curb and gutter placement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing as specified for formed concrete. If results are not acceptable, remove and replace with formed concrete.

1. Spill Gutters: Form and install curb and gutter with gutter pans that spill at ¼" per foot slope away from the curb in the following locations. Do not install curb and gutter that will pond water.

    a. Outside of the Public Right of Way: Provide spill gutter where curb and gutter is located adjacent to pavement surfaces that slope away from curb.
    b. Within the Public Right of Way: Slope gutter per NCDOT Standard Drawing 846.01.

L. Cold-Weather Placement: Comply with provisions of ACI 306R and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

1. When air temperature has fallen to or is expected to fall below 40 deg F (4 deg C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F (10 deg C) and not more than 80 deg F (27 deg C) at point of placement.
2. Do not use frozen materials or materials containing ice or snow.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise accepted in mix designs.

M. Hot-Weather Placement: Place concrete complying with ACI 305R and as specified when hot weather conditions exist.

1. Cool ingredients before mixing to maintain concrete temperature at time of placement to below 90 deg F (32 deg C). Mixing water may be chilled or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperature immediately before embedding in concrete.
3. Fog spray forms, reinforcing steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.6 CONCRETE FINISHING

A. Float Finish: Begin floating when bleed water sheen has disappeared and the 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 within a tolerance of 1/4 inch in 10 feet as determined by a 10-foot-long straightedge placed anywhere on the surface in any direction. Cut down high spots and fill low spots to ensure positive drainage and eliminate ponding. Refloat surface immediately to a uniform granular texture.

1. Medium-to-Fine-Textured Broom Finish: Draw a soft bristle broom across all site concrete sidewalk and pavement surfaces perpendicular to line of traffic to provide a uniform fine line texture finish.

B. Final Tooling: Tool edges of paving, gutters, curbs, and joints formed in fresh concrete with a jointing tool to a radius of ¼-inch unless indicated otherwise on the drawings. Repeat tooling of edges and joints after applying surface finishes. Eliminate tool marks on concrete surfaces.

C. Step Tread Grooves: Tool three (3) parallel grooves along entire top front edge of new concrete stair treads.

3.7 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with the recommendations of ACI 306R for cold weather protection and ACI 305R for hot weather protection during curing.

B. Evaporation Control: In hot, dry, and windy weather, protect concrete from rapid moisture loss before and during finishing operations with an evaporation-control material. Apply according to manufacturer's instructions after screeding and bull floating, but before floating.

C. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

D. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:

1. Moisture Curing: Keep surfaces continuously moist for not less than 7 days with the following materials:

    a. Water.
    b. Continuous water-fog spray.
    c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with a 12-inch lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's directions. Recoat areas subjected to heavy rainfall within 3 hours after initial application. Maintain continuity of coating and repair damage during curing period.

3.8 TRAFFIC MARKINGS

A. Cleaning: Remove all oil, dust, grease, dirt, loose rust, and other foreign material to ensure adequate adhesion.

B. Surface Preparation: Surfaces shall be cured, clean, dry and sound. Remove all peeling paint from existing surfaces. Concrete surfaces shall cure minimum 30 days. Concrete sealers or efflorescence of new concrete should be removed by extended weathering, etching or abrasive blasting.

C. Application Conditions: 50° min., 90° maximum (air, surface, and materials) at least 5° above dew point. Relative humidity 85% maximum.

D. Tinting: Mix colors per manufacturer’s specification. Only mix like paints (do not mix latex with acrylic or interior paints with exterior paints) to achieve required colors.

E. Apply play area markings at manufacturer’s recommended rates to provide minimum 15 mils dry thickness. Special care shall be given to laps and edges of stencils to prevent excessive film thickness.

F. Apply traffic paint with mechanical equipment to produce uniform straight edges. Apply at manufacturer's recommended rates to provide minimum 12 to 15 mils dry thickness.

3.9 FIELD QUALITY CONTROL TESTING

A. The Owner shall employ an independent testing and inspection agency to sample materials, perform tests, and submit test reports during concrete placement in accordance with Division 01 Section “Quality Control” and as follows:

1. When total quantity of a given class of concrete is less than 50 cu. yd., Architect may waive strength testing if adequate evidence of satisfactory strength is provided.

2. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing the in-place concrete.

B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. or fraction thereof of each concrete mixture placed each day.
2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below and when it is 80 deg F and above, and one test for each composite sample.
5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
6. Compressive-Strength Tests: ASTM C 39/C 39M; test one specimen at seven days and two specimens at 28 days.

    a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.

C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within one week of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.

F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.

G. Concrete paving will be considered defective if it does not pass tests and inspections.

H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.10 REPAIRS AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective, or does not meet the requirements of this Section.

B. Drill test cores where directed by Architect when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with portland cement concrete bonded to paving with epoxy adhesive.

C. Protect concrete 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.

D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep concrete paving not more than 2 days prior to date scheduled for Substantial Completion inspections.

E. Remove and replace concrete paving or curb and gutter that ponds water.

END OF SECTION 321313

SECTION 32 31 13 - CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Galvanized-steel chain link fabric.
2. Galvanized-steel framework.
3. Swing Gates.
4. Cantilevered Sliding Gates.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 31, Section "Earth Moving" for filling and grading work.
2. Division 32, Section “Gate Operators.”
3. Division 03, Section "Cast-in-Place Concrete" for concrete for post footings.

1.3 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 01 Specification Sections.

B. Product data in the form of manufacturer's technical data, specifications, and installation instructions for fence and gate posts, gates and accessories.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced Installer who has at least three years' experience and has completed at least five chain link fence projects with same material and of similar scope to that indicated for this Project with a successful construction record of in-service performance.

B. Single-Source Responsibility: Obtain chain link fences and gates, including accessories, fittings, and fastenings, from a single source.

C. Provide manufacturer’s standard limited warranty covering cantilever slide gate and truck assembly against failure resulting from normal use for period of 5 years from date of purchase. Failure is defined as any defect in manufacturing that prevents the gate from operating in a normal manner.

D. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified according to NETA ETT, or the National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3.

1.5 PROJECT CONDITIONS

A. Field Measurements: Verify layout information for fences and gates shown on the Drawings in relation to the property survey and existing structures. Verify dimensions by field measurements.

PART 2 - PRODUCTS

2.1 FABRIC

A. Steel Chain-Link Fence Fabric: Fabricated in one-piece widths for fencing 12 feet and less in height to comply with Chain Link Fence Manufacturers Institute (CLFMI) "Product Manual" and with requirements indicated below:

1. Mesh and Wire Size: Shall be as follows:

a. Standard Fence: 2-inch mesh, 0.148-inch diameter (#9 gauge) inner core, knuckled selvage top and bottom. Do not extend fabric above the top rail.
b. Temporary Construction Fence: Maximum 2-1/4 inch mesh, minimum 0.106-inch diameter (#12 gauge) inner core.

2. Standard Fence Fabric shall be zinc or aluminum coated with final vinyl-coated unless otherwise indicated on the drawings. Vinyl coating is not required on Temporary Construction Fence fabric.

a. Zinc-coated: Galvanized, ASTM A 392, Class II, with not less than 2 oz. zinc per sq. ft. of surface.
b. Aluminum-coated: ASTM A 491, Type I, 0.40 oz./sq. ft. (122 g/sq. m).
c. Vinyl-coated: ASTM F668, Class 2b thermally fused and bonded. Color: black unless noted otherwise. Coating shall be applied in addition to zinc or aluminum coating. Required mesh wire gauge shall be inner core gauge.

2.2 FITTINGS AND ACCESSORIES

A. Galvanized, ASTM A 153.

B. Polymer coating over galvanized. Provide electro-statically applied, 3-mil color polymer-coating on all fittings and accessories with the exception of Temporary Construction Fence.

2.3 FRAMING AND ACCESSORIES

A. Manufacture framing of galvanized steel, ASTM A 120 or ASTM A 123, with not less than 1.8 oz. Zinc per sq. ft. of surface. Provide electro-statically applied, 3-mil color polymer-coating on all framing and accessories where “PVC” or “vinyl” coated fence is indicated on the drawings.

1. End, corner and pull posts: Shall have minimum sizes and weights as follows:

Up to 6' fabric height (without privacy slats or wind screens), 2.375" OD steel pipe, 3.65 lbs. per linear foot or 3.5" x 3.5" roll-formed sections, 4.85 lbs. per linear foot.

Up to 6' height (with privacy slats or wind screens), 2.875" OD steel pipe, 5.79 lbs. per linear foot, or 3.5" x 3.5" roll-formed sections, 4.85 lbs. per linear foot.

Over 6' height, 2.875" OD steel pipe, 5.79 lbs. Per linear foot, or 3.5" x 3.5" roll-formed sections, 4.85 lbs. Per linear foot.

2. Line Post: Space line posts 10' o.c. maximum for standard fence and 8’ o.c. for fence with privacy slats or wind screens, unless otherwise indicated, of following sizes and weights:

Up to 6' fabric height (without privacy slats or wind screens), 1.9" OD steel pipe, 2.7 lbs. per linear feet, or 1.875" x 1.625" C-sections, 2.28 lbs. per linear foot.

Up to 6’ fabric height (with privacy slats or wind screens), 2.375" OD steel pipe, 3.65 lbs. per linear foot, or 2.25" x 1.875" H-sections, 2.64 lbs. per linear foot.

Over 8' fabric height, 2.875" OD steel pipe, 5.79 lbs. per linear foot, or 2.25" x 1.875" H-Sections, 3.26 lbs. per linear foot.

3. Swing Gate Posts: Furnish gate posts for supporting single gate leaf, or one leaf of a double gate installation, for nominal gate widths as follows:

Leaf Width	Gate Post	Lbs./Linear Foot
Up to 6 ft.	2.875" OD pipe	5.79
Over 6' to 13'	4.000" OD pipe	9.11
Over 13' to 18'	6.625" OD pipe	18.97
Over 18'	8.625" OD pipe	28.55

4. Top, Intermediate and Bottom Rails: Rail pipe sections shall not be less than 18' long and shall be fitted with couplings for connected lengths into a continuous run. The couplings shall be not less than 6' long, with 0.070 minimum wall thickness, and shall allow for expansion and contraction of the rail. Open seam outside sleeves shall be permitted only with a minimum wall thickness of 0.100". The rail shall pass through the line post tops. Rails shall be securely fastened to terminal posts by either pressed steel or malleable steel galvanized connections. Tension wire may be used in lieu of top and bottom rails for temporary construction fence only.

5. Tension Wire: Provide 7-gauge, coated coil spring tension wire (metal and finish to match fabric) and located at bottom and top of fabric.

6. Post Brace Assembly: Provide manufacturer's standard adjustable brace at end and gate posts and at both sides of corner and pull posts, with horizontal brace located at mid-height of fabric. Use 1.66" OD pipe, 2.27 lbs. per linear foot, or equal, for brace, and truss to line posts with 0.375" diameter rod and adjustable tightener.

7. Post Tops: Provide weather tight closure cap with loop to receive tension wire or top rail, one cap for each post.

8. Stretcher Bars: One-piece lengths equal to full height of fabric, with minimum cross-section of 3/16" x ¾". Provide one stretcher bar for each gate and end post, and for each corner and pull post, except where fabric is integrally woven into post. Space stretcher bar bands not over 15" o.c. to secure stretcher bars to end, corner, pull and gate posts.

9. Swing Gates: Fabricate perimeter frames of gates from minimum 1.9" OD pipe with finish to match fence framework. Assemble gate frames by welding or with special fittings and rivets for rigid connections, providing security against removal or breakage connections. Provide horizontal and vertical members to ensure proper gate operation and attachment of fabric, hardware and accessories. Space frame members maximum of 8' apart unless otherwise indicated. Provide same fabric as for fence, unless otherwise indicated. Install fabric with stretcher bars at vertical edges and at top and bottom edges. Attach stretcher bars to gate frame at not more than 15" o.c. Install diagonal cross-bracing, consisting of 3/8" diameter adjustable length truss rods on gates to ensure frame rigidity without sag or twist.

10. Swing Gate Hardware: Provide hardware and accessories for each gate, galvanized per ASTM A 153. Hinges shall be size and material to suit gate size, non-lift-off type, offset nominal height. Latch shall be forked type or plunger-bar type to permit operation from either side of gate, with

padlock eye as integral part of latch. Provide keeper for vehicle gates, which automatically engages gate leaf and holds it in open position until manually released. For double gates, provide gate stops consisting of mushroom type flush plate with anchors, set in concrete, and designed to engage center drop rod or plunger bar. Include locking device and padlock eyes as integral part of latch, permitting both gate leaves to be locked with single padlock.

11. Wire ties: For tying fabric to line posts, use wire ties spaces 12" o.c. For tying fabric to rails and braces, use wire ties spaced 24" o.c. For tying fabric to tension wire, use hog rings spaced 24" o.c. Manufacturer's standard procedure will be accepted if of equal strength and durability.

2.4 CANTILEVER SLIDE GATES

A. Gate frames: Fabricate chain link cantilever slide gates in accordance with ASTM F 1184, Type II, Class 2, using 2 inch (50 mm) square aluminum members, ASTM B 221, alloy and temper 6063-T6, weighing 0.94 lb/ft (1.39 kg/m). Weld members together forming rigid one-piece frame integral with top track. Provide 2 truck assemblies for each gate leaf, except as indicated for gates larger than 30’ (9144 mm).

1. Internal uprights: 2” x 2” (50 mm x 50 mm) aluminum members welded in gate frames, at 8’ (2438 mm) on center, subdividing frame into panels.

Gate Leaf Sizes	Cantilever Support (Overhang)
6 ft to 10 ft	6’-6”
11 ft to 14 ft	7’-6”
15 ft to 22 ft	10’-0”

B. Gate Frame Finish: Vinyl-Coated, Natural Aluminum.

C. Chain Link Filler Finish: Vinyl-coated, aluminized - ASTM A 491

D. Bracing: Provide diagonal adjustable length truss rods of 3/8” (9.5 mm) galvanized steel, in each panel of gate frames.

E. Top track/rail: Enclosed combination one-piece track and rail, aluminum extrusion with weight of 3.72 lb/ft (5.54 kg/m). Track to withstand reaction load of 2,000# (907.2 kg.).

F. Truck assembly: Swivel type, zinc die cast, with 4 sealed lubricant ball bearing rollers, 2 inches (50 mm) in diameter by 9/16” (14 mm) in width, and 2 side rolling wheels to ensure truck alignment in track. Mount trucks on post brackets using 7/8” (22 mm) diameter ball bolts with 1/2” (13 mm) shank. Truck assembly to withstand same reaction load as track, 2,000 # (907.2 kg.).

G. Gate hangers, latches, brackets, guide assemblies, and stops: Malleable iron or steel, galvanized after fabrication. Provide positive latch with provisions for padlocking.

H. Bottom guide wheel assemblies: Each assembly shall consist of two, 4” (100 mm) diameter rubber wheels, straddling bottom horizontal gate rail, allowing adjustment to maintain gate frame plumb and in proper alignment. Attach one assembly to each guide post.

I. Gates posts:

1. For gates under 31’-0” (9449 mm): galvanized steel 4” (101.6 mm) OD schedule 40 pipe, ASTM F 1083, weighing 9.1 lb/ft (13.6 kg/m). Provide 1 latch post and 2 support posts for single slide gates and 4 support posts for double slide gates. Finish to match fence.
2. For gates 31’-0” (9449 mm) or larger: 2 pairs of support posts for each leaf (dual 4” (100 mm) OD schedule 40 pipe), ASTM F 1083, weighing 9.1 lb/ft (13.6 kg/m) each. Posts connected by

welding 6 inch x 3/8 inch (12.7 x 9.5 mm) plate between posts as shown on drawings. Single posts require on 4" (100 mm) latch post. Finish to match fence.

2.5 CONCRETE

A. Concrete: Provide concrete consisting of portland cement per ASTM C 150, aggregates per ASTM C 33, and potable water. Mix materials to obtain concrete with a minimum 28-day compressive strength of 3000 psi. Use at least four sacks of cement per cu. yd., 1-inch maximum size aggregate, 3-inch maximum slump.

B. Packaged Concrete Mix: Mix dry-packaged normal-weight concrete conforming to ASTM C 387 with clean water to obtain a 2- to 3-inch slump.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Install fence to comply with ASTM F 567. Do not begin installation and erection before final grading is completed, unless otherwise permitted.

1. Apply fabric to outside of framework of Standard Site Fence.
2. Cut all bolts flush with nut. Leave no sharp protruding edges.

B. Excavation: Drill or hand-excavate (using post-hole digger) holes for posts to diameters and spacings indicated, in firm, undisturbed or compacted soil.

1. If not indicated on Drawings, excavate holes for each post to minimum diameter recommended by fence manufacturer, but not less than four times the largest cross section of post.

C. Setting Posts: Center and align posts in holes 3 inches above bottom of excavation. Space a maximum of 10 feet o.c., unless otherwise indicated. Space posts a maximum of 8 feet o.c. where privacy slats or wind screens are to be installed.

1. Protect portion of posts above ground from concrete splatter. Place concrete around posts and vibrate or tamp for consolidation. Check each post for vertical and top alignment and hold in position during placement and finishing operations.

a. Unless otherwise indicated, finish concrete footings 4 inches below grade and trowel to a crown to shed water.

b. Post of temporary construction fence may be driven directly into the ground provided adequate support can be maintained. Concrete footings shall be provided if fence posts become loose, unsecure, or otherwise unsafe.

D. Privacy Slats: Install slats vertically for privacy factor of 70 to 75, securely locked in place with horizontal locking strips in fence and gate locations shown on drawings.

3.2 GATE INSTALLATION

A. Install gates plumb, level, and secure for full opening without interference. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary. Install gates according to manufacturer's instructions, plumb, level, and secure.

3.3 GATE ADJUSTING

A. Gate: Adjust gate to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

3.4 GATE DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain gates.

END OF SECTION 32 31 13

SECTION 323119 – ORNAMENTAL FENCE

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Ornamental picket fencing and accessories.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 3, Section 03300 "Cast-in-Place Concrete" for concrete for post footings.

1.3 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product data in the form of manufacturer's technical data, specifications, and installation instructions for fence and gate posts, gates and accessories.

C. Shop drawings: Layout and elevations of fences and gates with dimensions, details, and finishes of components, accessories, and post foundations.

D. Samples: Manufacturer’s standard color selections.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who has at least three years' experience and has completed at least five ornamental fence projects with same material and of similar scope to that indicated for this Project with a successful construction record of in-service performance.

B. Single-Source Responsibility: Obtain fences and gates, including accessories, fittings, and fastenings, from a single source.

C. Manufacturer: Ameristar Fence Products, Inc., Tulsa, OK or approved equal. Products from qualified manufacturers having a minimum of 5 years experience manufacturing ornamental picket fencing will be acceptable by the architect as equal if they meet the following specifications for design, size, gauge of metal parts and fabrication.

D. Warranty: Provide manufacturer’s standard 20 year warranty that the ornimental fence system is free from defects in material and workmanship including cracking, peeling, blistering and corroding. Reimbursement for labor necessary to restore or replace components that have been found to be defective under the terms of manufactures warranty shall be guaranteed for five (5) years from date of original purchase.

1.5 PROJECT CONDITIONS

A. Field Measurements: Verify layout information for fences and gates shown on the Drawings in relation to the property survey and existing structures. Verify dimensions by field measurements.

PART 2 – PRODUCTS

2.1 ORNAMENTAL PICKET FENCE

A. 48-in high Montage II Steel Fence - Ornamental Steel, Majestic™Style, flush bottom rail treatment, 3-Rail style manufactured by Ameristar Fence Products, Inc., in Tulsa, OK, or approved equal. Color: Black.

B. Material: Steel for fence panels and posts shall conform to the requirements of ASTM A653/A653M, with a minimum yield strength of 45,000 psi (310 MPa) and a minimum zinc (hot-dip galvanized) coating weight of 0.90 oz/ft2 (276 g/m2), Coating Designation G-90.

C. Pickets: Steel, 14 Ga. Thick, 1-in square tubular members, Space pickets 3-1/2-in maximum face to face.

D. Rails: Steel, 0.105-in thick top wall, 0.105-in thick side wall, 1-3/4-in square tubular members.

E. Line Posts: Steel, 0.06-in thick, 2-1/2-in square tubular members. Space posts at 96-in on center.

F. Finish: Black, duplex application of an epoxy primer and an acrylic topcoat finish applied by manufacturer.

E. Gate Panic Bar: Provide panic bar and hardware to allow immediate egress from school. Bar shall have surface-mount strike with no open space gaps to eliminate pinching fingers anywhere on the bar. Assembly shall be weather resistant, anodized aluminum finish, stainless steel latch mechanism.

2.2 FABRICATION

A. Pickets, rails and posts shall be pre-cut to specified lengths. Rails shall be pre-punched to accept pickets.

B. Pickets shall be inserted into the pre-punched holes in the rails and shall be aligned to standard spacing using a specially calibrated alignment fixture. The aligned pickets and rails shall be joined at each picket-to-rail intersection by Ameristar's proprietary fusion welding process, thus completing the rigid panel assembly (Note: The process produces a virtually seamless, spatter-free good-neighbor appearance, equally attractive from either side of the panel).

C. The manufactured panels and posts shall be subjected to an inline electrodeposition coating (E-Coat) process consisting of a multi-stage pretreatment/wash (with zinc phosphate), followed by a duplex application of an epoxy primer and an acrylic topcoat. The minimum cumulative coating thickness of epoxy and acrylic shall be 2 mils (0.058 mm). The color shall be Black. The coated panels and posts shall be capable of meeting the performance requirements for each quality characteristic shown in Table 2 (Note: The requirements in Table 2 meet or exceed the coating performance criteria of ASTM F2408).

D. The manufactured fence system shall be capable of meeting the vertical load, horizontal load, and infill performance requirements for Industrial weight fences under ASTM F2408.

E. Swing gates shall be fabricated using 1.75" x 14ga Forerunner double channel rail, 2" sq. x 11ga. gate ends, and 1" sq. x 14ga. pickets. Gates that exceed 6' in width will have a 1.75" sq. x 14ga. intermediate upright. All rail and upright intersections shall be joined by welding. All picket and rail intersections shall also be joined by welding. Gusset plates will be welded at each upright to rail intersection. Cable kits shall be provided for additional trussing for all gates leaves over 6'.

2.3 SETTING CONCRETE

A. Concrete: Provide concrete consisting of portland cement per ASTM C 150, aggregates per ASTM C 33, and potable water. Mix materials to obtain concrete with a minimum 28-day compressive strength of 3000 psi. Use at least four sacks of cement per cu. yd., 1-inch maximum size aggregate, 3-inch maximum slump.

B. Packaged Concrete Mix: Mix dry-packaged normal-weight concrete conforming to ASTM C 387 with clean water to obtain a 2- to 3-inch slump.

PART 3 – EXECUTION

3.1 INSTALLATION

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

1. Cut all bolts flush with nut. Leave no sharp protruding edges.

B. Space posts uniformly unless otherwise indicated.

C. Concrete Set Posts: Drill hole in firm undisturbed or compacted soil. Holes shall have diameter 4 times greater than nominal outside dimension of post, and depths approximately 6" (152 mm) deeper than post bottom. Excavate deeper as required for adequate support in soft and loose soils, and for posts with heavy lateral loads. Set post bottom 36" (914 mm) below surface when in firm, undisturbed soil. Place concrete around post in a continuous pour. Trowel finish around posts and slope to direct water away from posts.

D. Check each post for vertical and top alignment, and maintain in position during placement and finishing operation.

E. Align fence panels between posts. Firmly attach rail brackets to posts with manufacturer supplied hardware, ensuring panels and posts remain plumb.

END OF SECTION 323119

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SECTION 324000 - SITE FURNISHINGS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Benches.
2. Refuse and Recycling Receptacles
3. Flagpoles.
4. Picnic Tables

1.2 SUBMITTALS

A. Product Data: For each product indicated.

B. Samples: For each type of exposed finish and for each color and texture required.

C. Maintenance data.

PART 2 - PRODUCTS

2.1 BENCHES

A. Products:

1. Maglin Site Furniture. #1-800-716-5506: 6’ long straight backless bench, recycled plastic (HDPE) seat slats, steel frame to have a powder coated finish, pedestal mounts, left to right slats. Model# LAYT_OGM1900-00103 or approved equal. – Color: Submit standard color options to Owner for selection.

B. Installation Method: Per manufacturer, surface mounted (anchored) to concrete sidewalk.

2.2 REFUSE / RECYCLING RECEPTACLES

A. Products:

1. Maglin Site Furniture. #1-800-716-5506: 32 gallon, heavy duty steel with E-Coat Rust Proofing Powdercoat finish. Steel sheet metal frame include steel lid and liners . Model# MTR-0600-00005 600 Series or approved equal. Surface Mounted (Anchored) to concrete sidewalk. Color: submit standard color options to Owner for selection.

2.4 FLAGPOLE

A. Products: Seamless, tapered aluminum tubing, clear anodized finish, 35-ft exposed height, manufacturer’s standard butt and top diameter. Provide complete with cleats, halyards, truck and collar.

B. Installation Method: Per manufacturer.

2.5 PICNIC TABLES

A. Products:
1. Wausau Tile. #(800) 388-8728: round modular 3 bench with ADA table, steel with metal powdercoat finish, portable. Model# MF1024 or approved equal. Color: submit standard color options to Owner for selection.

2. Wausau Tile. #(800) 388-8728: round modular 4 bench table, steel with metal powdercoat finish, portable. Model# MF1023 or approved equal. Color: submit standard color options to Owner for selection.

B. Installation Method: Per manufacturer; placed on concrete surface (NOT anchored).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Complete field assembly of site and street furnishings, where required.

B. Unless otherwise indicated, install site and street furnishings after landscaping and paving have been completed.

C. Install site and street furnishings level, plumb, true, and securely positioned at locations indicated on Drawings in accordance with manufacturer’s printed instructions.

D. Pipe Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with non-shrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

E. Install flagpoles per manufacturer’s instructions.

END OF SECTION 32 40 00

SECTION 329000 - PLANTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Seeded lawns, sod and “no-mow” areas.
2. Topsoil and soil amendments.
3. Fertilizers
4. Maintenance, guarantees and warranties.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 31, Section "Site Clearing" for protection of existing trees and planting, topsoil stripping and stockpiling, and site clearing.
2. Division 31, Section "Earth Moving" for excavation, filling, rough grading, and subsurface aggregate drainage and drainage backfill.
3. Division 31 Section “Erosion Controls” soil erosion and sedimentation control.

1.3 INDUSTRY STANDARDS

A. References: Some products and execution are specified in this Section by reference to published specifications or standards of the following:

The American Society for Testing and Materials (ASTM)
American Association of Nurserymen (AAN)
US Department of Agriculture (USDA)
NC Department of Agriculture (NCDA)
NC Composting Council (NCCC)

B. Landscape Contractor shall mean a registered “Landscape Contractor” as defined by the NC General Statute 89D (www.nclclb.com). Unless proper credentials and evidence of experience can be supplied to prove equal capabilities, only a Landscape Contractor licensed in the State of NC shall be permitted to perform the work.

1. The Landscape Contractor’s performance shall conform to the requirements in the most current edition of the NC Landscape Contractors Manual (NCLCM) as approved by the NC Board of Landscape Contractors. In the event the Landscape Contractor feels there is discrepancy between the NCLCM and the requirements of this Contract that could affect the quality of work; it is the Contractor’s responsibility to apprise the Owner and Landscape Architect of the issue.

1.4 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 01 Specification Sections.

B. Product certificates signed by manufacturers certifying that their products comply with specified requirements.

1. Manufacturer's certified analysis for standard products.
2. Label data substantiating that planting materials comply with specified requirements.

C. Certification of grass seed from seed vendor for each grass-seed mixture stating the botanical and common name and percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

D. Samples of each of the following:

1 Topsoil (1) 1-gal sized bag.

E. Qualification data for firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, at least fifteen names and address of architects and owners, total years of experience and landscape contractor's license number. If the landscape contractor hires a sub-contractor for seeding operations, the same references shall be required from them also.

F. Material test reports from qualified independent testing agency indicating and interpreting test results relative to compliance of the following materials with requirements indicated.

1. Analysis of existing topsoil and suitability as a medium for growing specified lawn. Include recommendations of amendments required to make existing topsoil suitable as a growing medium for specified lawn, if required.
2. Analysis of imported topsoil, if required due to unacceptability of existing topsoil to meet acceptable growing medium requirements for lawn.

G. Maintenance instructions recommending procedures to be established by Owner for maintenance of landscaping during an entire year. Submit before expiration of required maintenance periods.

H. All sod shall be from a certified sod producer and be blue tag certified in accordance with NCCIA and AOSCA.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced Installer who has completed landscaping work similar in material, design, and extent to that indicated for this Project and with a record of successful landscape establishment.

1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on the Project site during times that landscaping is in progress.

B. Testing Agency Qualifications: To qualify for acceptance, an independent testing agency must demonstrate to Architect's satisfaction, based on evaluation of agency-submitted criteria conforming to ASTM E 699, that it has the experience and capability to satisfactorily conduct the testing indicated without delaying the Work.

C. Topsoil Analysis: Furnish a soil analysis made by a qualified independent soil-testing agency stating percentages of organic matter, inorganic matter (silt, clay, and sand), deleterious material, pH, and mineral and plant-nutrient content of topsoil.

1. Report suitability of on-site topsoil for growth of applicable planting material. State recommended quantities of nitrogen, phosphorus, and potash nutrients and any limestone, aluminum sulfate, or other soil amendments to be added to produce a satisfactory topsoil at no additional cost to owner.

D. Preinstallation Conference: Conduct conference at Project site to comply with requirements of Division 01 Section "Project Meetings."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in containers showing weight, analysis, and name of manufacturer. Protect materials from deterioration during delivery and while stored at site.

B. Seed: Deliver seed in original sealed, labeled, and undamaged containers.

1.7 PROJECT CONDITIONS

A. Utilities: Determine location of above grade and underground utilities and perform work in a manner which will avoid damage. Hand excavate, as required. Maintain grade stakes until removal is mutually agreed upon by parties concerned.

B. Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify Landscape Architect before planting.

1.8 COORDINATION AND SCHEDULING

A. Temporary Seeding: In accordance with the schedule as detailed on the drawings.

1. In the event the Landscape Contractor is required to establish a temporary seeding cover due to the construction schedule, the Landscape Contractor is not relieved from providing the specified permanent seed mixture.
2. The Landscape Contractor is responsible for eradicating any temporary seed cover by means of mowing, thatching and using an herbicide approved by the Owner’s representative at the manufacturer’s recommended rate.

1.9 GRASS ESTABLISHMENT SCHEDULE

A. Refer to the Supplementary Conditions for Final Completion dates of grassed areas of the site.

B. Definitions:

1. Final Complete seeded or sprigged grass: A healthy, dense, weed free stand of the specified species of grass with 95% grass coverage as evaluated on a per square yard sample basis.
2. Final Complete sodded grass: An installed and rolled healthy sod, free of weeds and dead spots.

C. Complete Site: A complete installation of grass sod and/or stand of grass, germinated from seed or sprigs, on the complete site shall be established by the following date:

1. Complete Site (Seed, Sprig or Sod) Final Completion: *See Final Completion Date noted in contract documents.* Due to seasonal restrictions the specified date shall not be extended. Extension to the Contract Time will not change this date.

1.10 WARRANTY

A. General Warranty: The 12-month warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

B. Additional maintenance during 12-month warranty period for lawn, grass and sod is not required once areas have met 95% coverage, have met final acceptance and the Owner has assumed mowing/maintenance of these areas. Contractor agrees to repair or replace accessories that fail in materials, workmanship, or growth within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Death and unsatisfactory growth; except for defects resulting from abuse or incidents that are beyond Contractor's control.

2. Warranty Periods from Date of Final Completion:

a. Lawn, grass and sod (herbicide and fertilizer): 12 months

3. Areas seeded or sodded that are bare and not established at the end of the warranty period shall be re-seeded or re-sodded at no additional cost to the Owner.

4. Contractor is responsible for applying weed control herbicide and fertilizers during warranty period.

1.11 LAWN/GRASS MAINTENANCE

A. Begin maintenance of lawns and other grassed/sodded areas immediately after each area is planted and continue until acceptable lawn is established and accepted by the Owner, but for not less than the following periods:

1. Seeded Lawns/Grass and Naturalized Seed Areas: **Final Completion**.

a. When full maintenance period has not elapsed before end of planting/growing season, or if lawn is not fully established at that time (95% coverage as established on a per square yard sample basis), continue maintenance during next planting season until 95% coverage is established.

2. Sodded Lawns/Grass: **Final Completion.**

a. Sodded areas will be accepted at final inspection if –

1. Sodded areas are properly established.
2. Sod is free of bare and dead spots and without weeds.
3. Sodded areas have been mowed a minimum of twice.

B. Maintain and establish lawns by watering, fertilizing, weeding, mowing, trimming, replanting, and other operations. Roll, regrade, and replant bare or eroded areas and re-mulch to produce a uniformly smooth lawn.

C. Watering: Provide and maintain temporary piping, hoses, and lawn-watering equipment to convey water from sources and to keep lawns uniformly moist to a depth of 4 inches (100 mm). Following the date of project Final Completion, water shall be provided by contractor own water source (water truck, gator bag, etc.).

1. Supplement natural precipitation to provide a net rate of one inch of water per week or as required to maintain lawn in a thriving condition.
2. Watering shall conform to the time, volume and frequency recommendations of applicable governmental water conservation regulations.
3. Irrigate at minimum rate of once per day for two full weeks following date of seeding or sod installation.
4. Irrigate at minimum of once per week for remainder of maintenance period.

D. Mow lawns as soon as there is enough top growth to cut with mower set at specified height for principal species planted. Repeat mowing as required to maintain specified height without cutting more than 40 percent of the grass height at any mowing. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet.

E. Postfertilization: Apply fertilizer to lawn after first mowing and when grass is dry. Apply only from August through October.

1. Use fertilizer that will provide actual nitrogen of at least 1 lb per 1000 sq. ft. (0.5 kg per 100 sq. m) of lawn area or as required to maintain lawn in a thriving condition. A minimum of 50% of the nitrogen shall be in a slow release form.

1.12 STORMWATER CONTROL MEASURE, WETLAND MAINTENANCE

A. Begin maintenance of stormwater control measures (stormwater wetlands) immediately after each area is planted and continue until completion of the 12-month warranty period.

B. The area to be maintained shall include the wet and dry surfaces of the facility and perimeter areas within 15-ft of the water quality pool elevation, along with the inlet and outlet structures, embankments, emergency spillway, turf and plants.

1. Maintenance shall include all items listed in the Operation & Maintenance Plan listed on the drawings. Maintenance shall include, but not limited to, the following:

a. Keep dry and wet areas clean of trash and debris.
b. Repair of erosion. Re-seed any bare areas including top and slopes of embankments.
c. Keep inlet and outlet pipes, weirs, orifices, under-drains, and swales clear of blockages.
d. Remove accumulated sediment from riprap aprons.
e. Remove accumulated sediment forebay of wetlands and ponds if greater than 12-in of accumulation.
f. Prune shelf plants.
g. Remove invasive plants and algae.
h. Replace dead plants.
i. Replace/replenish mulch.
j. Other requirements of the Operation and Maintenance Plan on the drawings.

2. Perform inspections at least every two months and after every storm of greater than 1.5-in of rainfall. Perform maintenance as needed.
3. Final maintenance shall be performed immediately prior to the 11-month inspection.
4. Perform additional maintenance and repair resulting from the 11-month inspection.

5. Records of inspections and maintenance performed shall documented and supplied to the Owner at the completion of the warranty and maintenance period.

PART 2 - PRODUCTS

2.1 GRASS/LAWN MATERIALS

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with the Association of Official Seed Analysts' "Rules for Testing Seeds" for purity and germination tolerances.

1. Seed Mixture: Provide seed of grass species and varieties as specified in the plans and/or specifications.

2. Sod shall be as indicated on the plans and detail drawings. Provide machine cut, strongly rooted, certified turf grass sod, not less than two years old, free from weeds and undesirable native grasses and stripped not more than 24 hours before laying. Sod pad size shall be uniform thickness of 5/8", plus or minus ¼", measured at the time of cutting and excluding top growth and thatch.

2.2 TOPSOIL

A. Topsoil: ASTM D 5268, pH range of 5.5 to 7, 4 percent organic material minimum, free of stones 1 inch (25 mm) or larger in any dimension, and other extraneous materials harmful to plant growth. Sticks, roots, and clay clumps shall be removed from topsoil prior to spreading.

1. Topsoil Source: Reuse surface soil stripped and stockpiled on the site if adequate quantities exist. Verify suitability of surface soil to produce topsoil meeting requirements and amend when necessary. Screen topsoil of roots, plants, sods, stones greater than 1/2" diameter in general lawn areas and planting beds, clay lumps, and other extraneous materials harmful to plant growth. Screen topsoil prior to planting. If inadequate quantities of topsoil exist on-site contractor will be required to import pre-screened topsoil. A minimum depth of 3 inches shall be required.

2.3 SOIL AMENDMENTS

A. Lime: ASTM C 602, Class T, agricultural limestone containing a minimum 80 percent calcium carbonate equivalent, with a minimum 99 percent passing a No. 8 (2.36 mm) sieve and a minimum 75 percent passing a No. 60 (250 micrometer) sieve.

1. Provide lime in the form of dolomitic limestone.

B. Organic Compost: Organic compost of neutral character, decomposed, stable and weed-free meeting the US Composting Council standards.

C. Perlite: Horticultural perlite, soil amendment grade.

D. Peat Humus: Finely divided or granular texture, with a pH range of 6 to 7.5, composed of partially decomposed moss peat (other than sphagnum), peat humus, or reed-sedge peat.

E. Sawdust or Ground-Bark Humus: Decomposed, nitrogen-treated, of uniform texture, free of chips, stones, sticks, soil, or toxic materials.

1. When site treated, mix with at least 0.15 lb (2.4 kg) of ammonium nitrate or 0.25 lb (4 kg) of ammonium sulfate per cu. ft. (cu. m) of loose sawdust or ground bark.

F. Manure: Well-rotted, un-leached stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

G. Herbicides: EPA registered and approved, of type recommended by manufacturer.

H. Water: Potable.

I. Mycorrhizae: Applied to planting hole backfill or planting bed solid. Product shall be formulated for the moisture regime of the particular planting location (low, medium, high) contain a broad spectrum of mycorrhizae species, an organic bi-stimulant (2-2-2 preferred) and a water holding gel (low moisture locations only). Apply per manufacturer's recommendations.

2.4 FERTILIZER

A. Bonemeal: Commercial, raw, finely ground; minimum of 4 percent nitrogen and 20 percent phosphoric acid.

B. Superphosphate: Commercial, phosphate mixture, soluble; minimum of 20 percent available phosphoric acid.

C. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea-form, phosphorous, and potassium in the following composition:

1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency and as needed to maintain plant material and lawns in a thriving condition.

D. Slow-Release Fertilizer: Granular fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency and as needed to maintain plant material and lawns in thriving condition.

2.5 EROSION-CONTROL MATERIALS

A. Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches (150 mm) long.

B. Fiber Mesh: Biodegradable twisted jute or spun-coir mesh, 0.92 lb per sq. yd. (0.5 kg per sq. m) minimum, with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, 6 inches (150 mm) long.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive landscaping for compliance with requirements and for conditions affecting performance of work of this Section. Do not proceed with installation until unsatisfactory conditions have been corrected. Do not seed the site until the Landscape Architect has reviewed the final grades.

3.2 LAWN PLANTING PREPARATION

A. Limit subgrade preparation to areas that will be planted in the immediate future.

B. Loosen subgrade to a minimum depth of 8 inches. Remove stones larger than 1/2 inch (19 mm) in any dimension and sticks, roots, rubbish, and other extraneous materials. Remove excess gravel which will inhibit lawn establishment and survival.

C. Spread topsoil to depth required to meet thickness, grades, and elevations shown, after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen.

1. Place approximately 1/2 the thickness of topsoil required. Work into top of loosened subgrade to create a transition layer and then place remainder of the topsoil.

D. Preparation of Unchanged Grades: Where lawns are to be planted in areas unaltered or undisturbed by excavating, grading, or surface soil stripping operations, prepare soil as follows:

1. Remove and dispose of existing grass, vegetation, and turf. Do not turn over into soil being prepared for lawns.
2. Till surface soil to a depth indicated on soil test report, but at a minimum of 6 inches (150 mm). Apply required soil amendments and initial fertilizers and mix thoroughly into top 4 inches (100 mm) of soil. Trim high areas and fill in depressions. Till soil to a homogenous mixture of fine texture.
3. Clean surface soil of roots, plants, sods, stones, clay lumps, and other extraneous materials harmful to plant growth.
4. Remove waste material, including grass, vegetation, and turf, and legally dispose of it off the Owner's property.

E. Grade lawn and grass areas to a smooth, even surface with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit fine grading to areas that can be planted in the immediate future. Remove trash, debris, stones larger than 1 inch in any dimension and other objects that may interfere with planting or maintenance operations. Remove all glass, wire or other objects of any size which may cause injury.

F. Moisten prepared lawn areas before planting when soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

G. Restore prepared areas if eroded or otherwise disturbed after fine grading and before planting.

H. Contact Owner and Landscape Architect for review and approval of seedbed preparation and seeding methods prior to and during seeding operations.

3.3 SEEDING NEW LAWNS

A. Sow seed with a spreader or a seeding machine. Do not broadcast or drop seed when wind exceeds 5 mph (8 km/h). Evenly distribute seed by sowing equal quantities in 2 directions at right angles to each other.

1. Do not use wet seed or seed that is moldy or otherwise damaged in transit or storage.

B. Sow seed at the rates required to achieve 95% coverage prior to Final completion as determined on a per square yard basis.

C. Rake seed lightly into top 1/8 inch (3 mm) of topsoil, roll lightly, and water with fine spray. Remove surface rocks of greater than 1” diameter.

D. Protect seeded slopes 6:1 (H:V) and steeper against erosion with erosion-control blankets installed and stapled according to manufacturer's recommendations.

E. Protect seeded areas with slopes flatter than 6:1 against erosion by spreading straw mulch after completion of seeding operations. Spread uniformly at a minimum rate of 2 tons per acre (45 kg per 100 sq. m) to form a continuous blanket 1-1/2 inches (38 mm) loose depth over seeded areas. Spread by hand, blower, or other suitable equipment. Tack with liquid asphalt tack (9 gals/1,000 SF) or non-asphaltic tackifier.

F. If seeding occurs in summer months, protect seeded areas against hot, dry weather or drying winds by applying peat mulch within 24 hours after completion of seeding operations. Soak and scatter uniformly to a depth of 3/16 inch (4.8 mm) thick and roll to a smooth surface.

3.4 HYDROSEEDING NEW LAWNS

A. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogenous slurry suitable for hydraulic application.

1. Mix slurry with non-asphaltic tackifier.
2. Apply slurry uniformly to all areas to be seeded in a 2-step process. Apply first slurry application at the minimum rate of 500 lb per acre (5.5 kg per 100 sq. m) dry weight but not less than the rate required to obtain specified seed-sowing rate. Apply slurry cover coat of fiber mulch at a rate of 1000 lb per acre (11 kg per 100 sq. m).

3.5 RECONDITIONING LAWNS

A. Recondition existing lawn areas damaged by Contractor's operations, including storage of materials or equipment and movement of vehicles. Also recondition lawn areas where settlement or washouts occur or where minor regrading is required.

B. Remove sod and vegetation from diseased or unsatisfactory lawn areas; do not bury into soil. Remove topsoil containing foreign materials resulting from Contractor's operations, including oil drippings, fuel spills, stone, gravel, and other construction materials, and replace with new topsoil.

C. Where repairable lawn remains, as determined by the Owner, mow, dethatch, core aerate, and rake heavily and deeply. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergence herbicides.

D. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of it off the Owner's property.

E. Till stripped, bare, compacted or otherwise unrepairable areas thoroughly to a depth of 8 inches.

F. Apply required soil amendments and initial fertilizers and mix thoroughly into top 4 inches (100 mm) of soil. Provide new planting soil as required to fill low spots and meet new finish grades.

G. Apply seed and protect with straw mulch as required for new lawns.

H. Water newly planted areas and keep moist until new grass is established.

3.6 SODDING NEW LAWNS

A. Lay sod to form solid, uniform mass with tightly fitted joints. "Butt" ends and sides of sod strips. Do not overlap sod strips. Stagger strips to offset joints in adjacent courses. Lay sod strips across slopes and perpendicular to drainage flow. Tamp or roll lightly to ensure contact with subgrade.

B. Secure with pegs or staples at spacing recommended by the sod grower and supplier and as approved by the Landscape Architect and Owner. If pegs or staples are used for athletic fields, they shall be removed upon full establishment prior to final acceptance.

C. Water sod with fine spray immediately after planting. Water daily during first two weeks of establishment to maintain soil to depth of 4".

D. At no time shall sodded turf be allowed to grow over 3 inches in height. Throughout this period, the target mowing height shall be 1.5 inches. At no time shall more than 50% of the turf height be removed in any three-day period by mowing or other maintenance activity.

E. Sodded turf shall be fertilized according to the monthly application rates recommended in Carolina Lawns for the utilized grass or at reduced rate if instructed by the Landscape Architect.

F. Weed control shall be provided as necessary to prevent the establishment or proliferation of a weed species and to achieve acceptable turf at time of initial Acceptance.

G. Remove all poly mesh netting prior to placement and dispose of off-site.

3.7 INSPECTION AND ACCEPTANCE

A. When landscape work is completed, including maintenance, Architect will, upon written request, make a final inspection to determine acceptability.

B. At time of inspection for initial Acceptance, turf shall have been freshly mowed within the last 48 hours. Turf shall be healthy, of uniform color and exhibiting signs of good growth. A minimum of 95% of the specified seeding area shall be covered in established turf possessing both stolens (i.e. runners) and rhizomes. There shall be no bare areas greater than 4 sq. ft. or 1.5 ft. in any dimension. Seedling plants not having reached tiller stage (i.e. runner producing) shall be considered bare area. Turf shall be 100% free of noxious and perennial weeds and relatively free of annual weeds.

C. At time of inspection for initial Acceptance, sodded and sprigged turf shall have been freshly mowed within the last 48 hours. Turf shall be healthy, of uniform color and exhibiting good growth. A minimum of 100% of the specified turf area shall be covered in sod that has been installed for a minimum six weeks. Turf shall be 100% free of all weeds.

E. When inspected landscape work does not comply with requirements, replace rejected work and continue specified maintenance until re-inspected by Architect and found to be acceptable. Remove rejected plants and materials promptly from project site.

3.8 CLEANUP AND PROTECTION

A. During landscaping, keep pavements clean and work area in an orderly condition.

B. Protect landscaping from damage due to landscape operations, operations by other contractors and trades, and trespassers. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged landscape work as directed.

3.9 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of it off the Owner's property unless an agreement is made with the Owner otherwise.

3.10 FIELD QUALITY CONTROL

A. Owner’s Independent Testing Agency Services: Allow testing agency to evaluate and test each subgrade and each fill or backfill layer. Do not proceed until test results for previously completed work verify compliance with requirements.

B. Pond and Wetland Imperviousness: Following completion of new permanent constructed wetlands, fill pond or wetland with water, measure and record water level every 24-hrs for a period of three days with no precipitation with time/date stamped photos. Provide water level measurements to Architect. Do not proceed with final planting until imperviousness is confirmed by Landscape Architect.

END OF SECTION 329000

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SECTION 331000 – SITE WATER SYSTEMS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes water systems piping for potable water service and fire protection service outside the building.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 21 Sections for fire protection systems inside building.
2. Division 22 Sections for water distribution systems inside building.

1.3 SYSTEM PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure Ratings: Except where otherwise indicated, the following are minimum pressure requirements for water system piping.

1. Underground Piping: 150 psig.
2. Underground Piping, Downstream of Fire Department Connections: 200 psig.

1.4 SUBMITTALS

A. General: Submit the following according to Conditions of the Contract and Division 1 Specification Sections.

B. Product data, including pressure rating, rated capacity, and settings of selected models for the following:

1. Valves, indicator posts and valve boxes.
2. Fire hydrants and fire department connections.
3. Identification materials and devices.
4. Pipe and Fittings.
5. Meter vaults and boxes.
6. Backflow prevention devices and enclosures.
7. Tapping sleeves and saddles.

C. As-Built survey of installed water system. Perform and submit as-built survey as soon as possible following installation of water main piping and appurtenances. Survey shall be submitted at least 60-days prior to needed use of water main.

D. Record drawings at Project closeout of installed water system piping and products according to Division 1 Section "Closeout Procedures."

E. Test reports specified in "Field Quality Control" Article in Part 3. Submit test reports at least 60-days prior to needed use of water main.

1.5 QUALITY ASSURANCE

A. All materials, construction methods and testing shall comply with the requirements of the City of Goldsboro Engineering Department.

B. Provide listing/approval stamp, label, or other marking on equipment made to specified standards.

C. Listing and Labeling: Provide equipment and accessories that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in "National Electrical Code," Article 100.
2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

D. Product Options: Water systems specialties and accessories are based on specific types, manufacturers, and models indicated. Components by other manufacturers but having equal performance characteristics may be considered, provided deviations in dimensions, operation, and other characteristics do not change design concept or intended performance as judged by Architect. The burden of proof of equality of products is on Contractor. Refer to Division 1 Section "Substitution Procedures."

E. All work within any NCDOT right-of-way shall conform to the requirements of the current version of the NCDOT's Policies and Procedures for Accommodating Utilities on Highway Rights of Way, the provisions and conditions of the encroachment agreement(s), and other applicable NCDOT standards and policies. The encroachment agreement(s) are considered part of the project specifications by reference. Copies of the agreement(s) will be provided upon request from the Architect.

F. As-Built Survey: As-built survey shall be signed and seal by a NC Professional Land Surveyor and shall include the following:

1. All fire hydrants and water valve sizes and locations with no less than two primary reference dimensions from permanent above grade features.
2. Locations of bacteriological sampling points.
3. Pipe materials and sizes.
4. Other water system components such as meters, backflow preventers, etc.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Transport: Prepare valves, including fire hydrants, for shipping as follows:

1. Ensure that valves are dry and internally protected against rust and corrosion.
2. Protect valves against damage to threaded ends, flange faces, and weld ends.
3. Set valves in best position for handling. Set valves closed to prevent rattling.

B. Storage: Use the following precautions for valves, including fire hydrants, during storage:

1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
2. Protect valves from weather. Store valves indoors and maintain temperature higher than ambient dew point temperature. Support valves off ground or pavement in watertight enclosures when outdoor storage is necessary.

C. Handling: Use sling to handle valves and fire hydrants whose size requires handling by crane or lift. Rig valves to avoid damage to exposed valve parts. Do not use handwheels or stems as lifting or rigging points.

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

E. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

F. Protect flanges, fittings, and piping specialties from moisture and dirt.

G. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Verify that water system piping may be installed in compliance with original design and referenced standards.

C. Site Information: Reports on subsurface condition investigations made during the design of the Project are available for informational purposes only; data in reports are not intended as representations or warranties of accuracy or continuity of conditions (between soil borings). Owner assumes no responsibility for interpretations or conclusions drawn from this information.

1.8 SEQUENCING AND SCHEDULING

A. Coordinate connection to water main with utility company.

B. Coordinate with pipe materials, sizes, entry locations, and pressure requirements of building fire protection and building water distribution systems piping.

C. Coordinate with other utility work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work are specified herein. Products by other manufacturers having equal performance characteristics may be considered, however approval must be acquired by the Contractor from City of Goldsboro.

2.2 PIPES AND TUBES

A. Ductile-Iron Pipe: AWWA C150 and C151, Pressure Class 350. All ductile-iron pipe shall be listed by ANSI/NSF Standard 61 for potable water contact.

1. Lining: AWWA C104, cement mortar, seal coated.
2. Gaskets, Glands, and Bolts and Nuts: AWWA C111.
3. Push-On-Joint-Type Pipe: AWWA C111, rubber gaskets.
4. Mechanical-Joint-Type Pipe: AWWA C111, rubber gaskets, ductile- or cast-iron glands, and steel bolts and nuts.
5. Coating: AWWA C151, bituminous coating.
6. Restrained Joint Pipe: All restrained joint ductile iron pipe unless otherwise specified shall be of the boltless restrained joint type. For installations requiring welded locking rings, the rings shall

be factory welded. The restrained joints shall provide a minimum of 4-degrees of deflection for pipe sizes, 4-inches through 12-inches in diameter. All proprietary pipe restraint systems shall be approved by the City of Goldsboro and provided in compliance with all standards for coatings, linings, pressure classes, etc. as required for ductile iron pipe. All restrained joint pipe shall be installed based on laying conditions, pressure class, etc. as required for typical ductile iron pipe.

B. 3-in and smaller Pplyvinyl Chloride (PVC) Pipe: ASTM D 2241, ASTM D 2672, SDR 21, gasket joints or ASTM D 1785, Sch-40, solvent joints. All PVC pipe shall be NSF Listed for potable use and shall confirm to NSF Standard 61.

1. Solvent Cement: ASTM D 2564.
2. Primer: ASTM F 656.

C. 4-in thru 12-in Polyvinyl Chloride (PVC) Pipe: AWWA C-900, Class 200, DR 14. All PVC pipe shall be NSF Listed for potable use and shall confirm to NSF Standard 61.

D. Copper Tube: ASTM B 88, Type K, seamless water tube, annealed temper. All copper pipe shall be NSF Listed for potable use.

E. Steel Encasement Pipe: High strength steel, spiral welded or smooth-wall seamless per ASTM A 139 and ASTM A 283, grade “2” steel with a min. yield strength of 35,000-psi, min. wall thickness of 0.375-in. Exterior shall be coated with two coats of a compatible black epoxy with a total dry film thickness of 10 mils per coat. Epoxy coating shall be Tnemec Hi-Build Tneme-Tar Series 46H-413, or approved equal. Pipe shall be coated inside and outside in accordance with AWWA C203 and any additional requirements of the NCDOT. Pipe ends shall be right-angled and shall be compatable to receive a “Dresser style 62” – Type I or approved equal mechanical transition coupler.

2.3 PIPE AND TUBE FITTINGS

A. Ductile-Iron and Cast-Iron Pipe Fittings: AWWA C110, ductile-iron or cast-iron, 250-psig minimum pressure rating; or AWWA C153, ductile-iron compact fittings, 350-psig pressure rating. All ductile-iron fittings shall be listed by ANSI/NSF Standard 61 for potable water contact.

1. Lining: AWWA C104, cement mortar.
2. Gaskets: AWWA C111, rubber.
3. Joints: AWWA C111, mechanical joint, all bell.
4. Coating: AWWA C151, bituminous coating.

B. Copper Tube Fittings: AWWA C800, flared copper type or compression type brass fittings. No joints or couplings shall be allowed within the public right-of-way. All copper fittings shall be NSF Listed for potable use.

C. PVC Plastic Fittings: ASTM D 2466, Sch-40. All PVC fittings shall be NSF Listed for potable use and shall confirm to NSF Standard 61. Fittings shall be manufactured in the United States from virgin rigid PVC vinyl compounds with a Cell Class of 12454 per ASTM D 1784. Pipe and fittings shall be manufactured as a system and be the product of one manufacturer.

1. Solvent Cement: ASTM D 2564.
2. Primer: ASTM F 656.

2.4 VALVES

A. Nonrising Stem Gate Valves, 1.5-inches and Smaller: MSS SP-80; body and screw bonnet of ASTM B 62 cast bronze; with Class 125 threaded ends, solid wedge, nonrising copper-silicon alloy stem, brass

packing gland, polytetrafluoroethylene (PTFE)-impregnated packing, and malleable-iron handwheel. Valves shall be certified low-lead per NSF.

B. Curb Stop Ball Valves 2 Inches and Smaller: 300-psi, AWWA C800, certified low-lead per NSF. Bronze body, ground-key plug or ball, and wide tee head, with inlet and outlet matching service piping material. Provide 2-inch wrench nut adapter on each valve.

C. Nonrising Stem Gate Valves 2 Inches and Larger: AWWA C509, resilient seated; bronze stem, cast-iron or ductile-iron body and bonnet, stem nut, 200-psig working pressure, mechanical joint ends.

D. Rising Stem Gate Valves 2 Inches and Larger for installation in vaults or other enclosure: AWWA C509, resilient seated; OS&Y, bronze stem, cast-iron or ductile-iron body and bonnet, stem nut, 200-psig working pressure, flanged ends.

E. Post Indicator Valves: NRS, UL 262, FM approved, iron body and bonnet with flange for indicator post, bronze seating material, inside screw, 175-psig working pressure, mechanical joint ends.

F. Valve Boxes: Valve Boxes shall be cast iron, screw type, with a 5 inch opening and "water" stamped on the cover. The cover shall be 6-inches in depth. All valve box assemblies and covers shall be cast from Class 35 gray iron and domestically made and manufactured in the USA.

G. Indicator Posts: UL 789, FM-approved, vertical type, cast-iron body with operating wrench, extension rod, and adjustable cast-iron barrel of length required for depth of bury of valve. Post indicator valves (PIVs) on fire protection systems shall be equipped with a supervisory switch.

H. Tapping Sleeve and Tapping Valve: Complete assembly, including tapping sleeve, tapping valve, and bolts and nuts. Use sleeve and valve compatible with tapping machine.

1. Tapping Sleeve: Stainless steel tapping sleeves shall have a stainless steel flange and be provided in a two piece assembly with a full circumferential gasket with tabbed gasket holding assembly and ¾-inch test plug. The back band shall be a minimum 14 gauge stainless steel and the front band (where the outlet is located) shall be a minimum 12 gauge stainless steel. The bolt bars shall be a minimum 7 gauge stainless steel. All stainless steel tapping sleeves shall be manufacturer rated for a working pressure of 200-psi or greater and air tested to 100-psi for 8 minutes before a tap is made.

2.5 WATER METERS

A. Water services greater than 2-inches shall have the meter and bypass line located within a precast concrete vault. All piping and valves shall have flanged connections. There shall be isolation gate valves on both sides of the meter as well as one on the bypass line. Gate valves within the vault shall meet the above requirements of AWWA C509 for non-rising stem gate valves, but shall be provided with hand wheel operators. A standard buried gate valve with 2-inch nut shall be provided between the main and the vault. Link seals shall be used where the pipe enters and exits the vault.

B. Meter vaults and access doors shall meet HS-20 loading requirements and shall be located outside of travel areas. Pedestrian rated covers shall not be used regardless of where they are located. The access double doors shall be aluminum with a flush drop lift handle, stainless steel hinges and bolts, a stainless steel slam lock, an automatic hold open arm, and compression springs to allow for easy opening. Vaults for 3 and 4 inch meters shall be approximately 8-feet by 10-feet in size. Six inch meter vaults shall be approximately 9-feet by 12-feet. To ensure positive drainage, the vault shall be tied into the existing storm drainage system. If positive drainage is unobtainable, a sump pump shall be located and operated in the vault.

C. Water meters shall be set by the City of Goldsboro. The Contractor shall coordinate purchase and installation directly with the City of Goldsboro. Contractor is responsible for all meter costs and installation fees

2.6 FIRE HYDRANTS

A. Hydrants shall be manufactured by American Darling Hydrants or other approved with a minimum valve opening of 4 1/2 inches.

1. Hydrants shall be furnished with a 4 ½ inch steamer and double 2 1/2 inch hose connections with caps and chains, National Standard Threads, mechanical joint, 1 1/2 inch pentagon operating nut, open left, painted fire hydrant red, bronze to bronze seating, a minimum 4 foot bury depth with a break away ground line flange and break away rod coupling.
2. The hydrant bonnet will be designed with a sealed oil or grease reservoir with O-ring seals and a Teflon thrust bearing.
3. Fire hydrant caps shall be attached to the body of the hydrant with a minimum 2/0 twist link, heavy duty, non-kinking, machine chain.
4. All fire hydrants shall be designed and rated for a working pressure of 250-psi or greater.

2.7 FIRE DEPARTMENT CONNECTIONS

A. Exposed, Sidewalk Fire Department Connections: UL 405, cast-brass body, lead-free, with thread inlets according to NFPA 1963 and matching local fire department hose threads, and threaded NPS bottom outlet. Include lugged cap, gasket, and chain; lugged swivel connection and drop clapper for each hose connection inlet; 18-inch high brass sleeve; and round sidewalk escutcheon plate marked “STANDPIPE” in 2-in letters. Connections shall be two 2 ½ inch inlets and 4 inch outlet.

B. Wafer Check Valve: UL Listed/FM Approved, lead free, ductile iron body, bronze clapper and seat ring, ‘O’ ring seals, stainless spring closure, with ½” ball drip valve below seat to allow valve to drain water from FDC.

C. Signage: Approx. 18”x10”, steel, white background with min. 6” red lettering, marked FDC, mounted on a galvanized steel pole with concrete footing. Mounting height to bottom of sign: 5-ft. min.

2.8 BACKFLOW PREVENTERS

A. General: As listed as approved by the Standard Specifications and Details Manual of the City of Goldsboro Engineering Department.

B. Reduced Pressure (RP or RPZ) Backflow Preventers – ¾” thru 2”: ASSE 1013, AWWA C511, CSA B64 Certified and USC Foundation for Cross Connection Control and Hydraulic Research approved, lead-free, with full port, resilient seated ball valve shut-off valves and ball valve test cocks. Include 2 spring loaded, center stem guided check valves and one hydraulically dependent differential relief valve.

C. Reduced Pressure (RP or RPZ) Backflow Preventers – 2-1/2” thru 10”: ASSE 1013, AWWA C511, CSA B64 Certified and USC Foundation for Cross Connection Control and Hydraulic Research approved, FM approved or UL listed, lead-free, with OS&Y gate valves on inlet and outlet, and strainer on inlet. Include test cocks and pressure-differential relief valve with ASME A112.1.2 air gap fitting located between 2 positive-seating check valves for continuous-pressure application. Assembly shall be of a compact design utilizing a flow orientation of inlet flow vertical up, outlet flow vertical down at the direct outlet of the gate valves.

D. Reduced Pressure Detector Assembly (RPDA) Backflow Preventers – 2-1/2” thru 10”: ASSE 1047, USC Foundation for Cross Connection Control and Hydraulic Research approved, FM approved and UL listed,

lead-free, with OS&Y gate valves on inlet and outlet, and strainer on inlet. Include test cocks and pressure-differential relief valve with ASME A112.1.2 air gap fitting located between 2 positive-seating check valves and test cocks, and bypass with displacement-type water meter, valves, and reduced pressure backflow preventer, for continuous-pressure application. Assembly shall be of a compact design utilizing a flow orientation of inlet flow vertical up, outlet flow vertical down at the direct outlet of the gate valves. Gate valves on backflow preventers on fire protection systems shall be equipped with supervisory switches.

2.9 PROTECTIVE ENCLOSURES

A. General: Manufactured, ASSE 1060 certified, weather-resistant enclosure designed to protect aboveground water piping equipment or specialties. Enclosures shall be sized as required for access and service of protected unit. Enclosures for compact design backflow preventors shall be no larger than 64”(L)x60”(W)x60”(H). Enclosures shall be as manufactured by Hot Box or approved equal.

1. Housing: Reinforced-aluminum or reinforced-fiberglass construction with factory applied paint. Paint color to be selected by Designer from manufacturer’s standard color choices. Unpainted aluminum exterior will not be allowed.
2. Drain opening: Sized to alleviate a full release by the backflow preventer.
3. Access doors with locking device.
4. Insulation inside housing.
5. Thermostatically controlled electric heater (for 2-1/2” or larger backflow preventers) or plug-connected self-limiting temperature control pipe heating cable (for 2” and smaller backflow preventers) and connection to power supply. Heating equipment shall be designed and furnished by the enclosure manufacturer and shall be rated/listed for damp/wet locations.
6. Concrete base slab: 4 inch thick of dimensions required to extend at least 6 inches beyond edges of housing. Provide PVC sleeves at pipe penetrations of slab.
7. Anchoring devices to attach housing to base with stainless steel mounting hardware.
8. Coordination: Coordinate with other trades for installation of electrical services, GFI, tamper switches, temperature sensors, and connections to fire alarm systems as applicable. Locate GFI and other electrical components away from water discharge from backflow devices.

2.10 ALARM DEVICES

A. Supervisory Switches: Single pole, double throw; designed to signal valve in other than fully open position.

2.11 ANCHORAGES

A. Clamps, Straps, and Washers: ASTM A 506, steel.

B. Rods: ASTM A 575, steel.

C. Rod Couplings: ASTM A 197, malleable iron.

D. Bolts: ASTM A 307, steel.

E. Cast-Iron Washers: ASTM A 126, gray iron.

F. Concrete Reaction Backing: Portland cement concrete mix, 3000 psi.

1. Cement: ASTM C 150, Type I.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.

4. Water: Potable.

G. Wedge Action Retainer Glands: All wedge action retainer glands shall be manufactured as a one piece retainer gland for use with mechanical joints and shall be rated to provide restraint up to 350-psi pressure rating for sizes through 16-inches.

1. Approved wedge action retainer glands shall be made of ductile iron, coated with a manufacturer applied epoxy coating or polyester powder coating.
2. In cases where wedge action retainer glands are approved for pipe restraint of fire hydrant supply lines or other applications, the entire hydrant supply line shall be restrained.
3. Wedge action retainer gland connections to push on pipe are not approved.

2.12 IDENTIFICATION

A. Metallic-Lined Plastic Underground Warning Tapes: The water main marking tape shall be approved by the City of Goldsboro. The marking tape shall be made of polyethylene (or approved equivalent) material, 6-inches wide and a minimum of 6 millimeters thick. The marking tape shall have detectable markers embedded in the tape and spaced adequately to provide continuous detection along the tape from above the buried pipe at final grade. The tape shall be blue in color and shall be marked with words “CAUTION WATER LINE BURIED BELOW” (or an approved equivalent wording). The wording shall be repetitive along the full length of the tap.

B. Copper Tracer Wire: #12 gauge solid (bare) copper and continuous to the greatest extent possible. The tracer wire shall be securely bonded together at all wire joints with an approved industrial crimp connector to provide electrical continuity. Refer to City of Goldsboro Standard Specifications and Details Manual for additional information.

PART 3 - EXECUTION

3.1 GENERAL

A. All construction shall conform to the requirements of the City of Goldsboro Engineering Department and the NCDOT as applicable in addition to the requirements state herein.

3.2 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.3 SERVICE ENTRANCE PIPING

A. Extend water system piping and connect to water supply source and building water distribution and fire protection systems in locations and pipe sizes indicated.

1. Terminate domestic water system piping at 5-feet outside building wall until building water systems are installed. Terminate piping with caps, plugs, or other fittings as required for piping material. Make connections to building water system when those systems are installed.
2. Terminate fire protection water system 12-in above finish floor elevation within building with caps, plugs, or flanges as required for piping material. Coordinate exact location with fire protection contractor. Install restrained joints for buried piping within 60 inches of building. Use restrained-joint pipe and fittings, thrust blocks, anchors, tie-rods and clamps, and other supports at vertical and horizontal offsets.

3.4 JOINT CONSTRUCTION

A. Ductile-Iron Piping Gasketed Joints: Construct joints according to AWWA C600.

B. Restrained-Joint Pipe and Fittings at vertical and horizontal bends.

C. Flanged Joints: Align flanges and install gaskets. Assemble joints by sequencing bolt tightening. Use lubricant on bolt threads. Flanged joints shall be used in vaults or above grade installations only.

D. PVC Joints: Solvent cement joints shall be made in a two-step process with primer and solvent cement per ASTM D 2672.

3.5 PIPING SYSTEMS - COMMON REQUIREMENTS

A. General Locations and Arrangements: Drawings indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated except where deviations to layout are approved on coordination drawings.

B. Install piping at indicated slope.

C. Install components having pressure rating equal to or greater than system operating pressure.

D. Install piping free of sags and bends.

E. Locate groups of pipes parallel to each other, spaced to permit valve servicing.

F. Install fittings for changes in direction and branch connections.

G. Piping Connections: Except as otherwise indicated, make piping connections as specified below within vaults or above-ground. Do not use flanges, unions or keyed couplings at underground installations.

1. Above grade: Install unions, in piping 2 inches and smaller, adjacent to each valve and at final connection to each piece of equipment having 2-inch or smaller threaded pipe connection.
2. Above grade: Install flanges, in piping 2-1/2 inches and larger, adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.
3. Below grade: Join copper pipe with flared copper type brass fittings.
4. Below grade: Join ductile iron pipe with push-on joints. Join fittings with mechanical joints.

3.6 PIPING INSTALLATION

A. Water Main Connection: Tap water main with size and in location as indicated according to requirements of water utility.

1. Install tapping sleeve and tapping valve according to manufacturer's installation instructions.
2. Install tapping sleeve on pipe to be tapped. Position flanged outlet for gate valve.
3. Install gate valve onto tapping sleeve. Comply with AWWA C600. Install valve with stem pointing up and with cast-iron valve box.
4. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Remove tapping machine and connect water service piping.
5. Install service clamps and corporation stops in size, quantity, and arrangement required by utility company standards and according to manufacturer's installation instructions.
6. Install service clamps on pipe to be tapped. Position outlet for corporation stop.
7. Install corporation stops into service clamps. Install valve with stem pointing up and with cast-iron valve box.
8. Install curb stop in service piping with head pointing up and with cast-iron service box.

9. Install manifold for multiple taps in water main.
10. Use drilling machine compatible with service clamp and corporate stop. Drill hole in main. Remove drilling machine and connect water service piping.

B. Comply with requirements of NFPA 24 for materials and installation.

C. Install ductile-iron pipe and ductile-iron and cast-iron fittings according to AWWA C600.

D. Install PVC pipe (3-in and smaller) according to ASTM D 2774 and ASTM F 1668.

E. Install piping with minimum cover over the top of pipe of 36 inches to finished grade.

F. Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or a combination of both.

G. Install and test fire protection piping and appurtenances in accordance with the specific requirements of the City of Goldsboro and applicable NFPA requirements.

3.7 ANCHORAGE INSTALLATION

A. Anchorages: Install anchorages or restrained joint pipe and fittings for tees, plugs and caps, bends, crosses, valves, and hydrant branches. Include anchorages for the following piping systems:

1. Gasketed-Joint, Ductile-Iron Piping: According to AWWA C600.
2. Fire Service Piping: According to NFPA 24.

B. Apply full coat of asphalt or other acceptable corrosion-retarding material to surfaces of installed ferrous anchorage devices.

3.8 FIRE HYDRANT INSTALLATION

A. Install fire hydrants as indicated on the Drawings.

B. Orient pumper nozzle hydrant toward nearest fire vehicle travel way.

3.9 ROUGHING-IN FOR WATER METERS

A. Install roughing-in piping and specialties for water meter installation as indicated on the Drawings and according to City of Goldsboro’s requirements.

3.10 PIT CONSTRUCTION AND INSTALLATION

A. Construct pits of poured-in-place concrete or provide precast concrete pits of dimensions indicated, with access frame and cover, ladder, and drain. Include sleeves with waterproof mechanical sleeve seals for pipe entry and exit.

B. Connect area drain outlet to storm drain

3.11 BACKFLOW PREVENTER INSTALLATION

A. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install according to plumbing and health department authorities having jurisdiction.

B. Do not install bypass around backflow preventer.

C. Do not install reduced-pressure-principle-type in pit.

D. Support backflow preventers, valves, and piping on 3000-psi minimum, portland-cement-mix concrete piers.

E. Contractor shall contract with qualified personnel to perform and provide certification of installed backflow prevention devices.

3.12 FIRE DEPARTMENT CONNECTION INSTALLATION

A. Install fire department connections in locations indicated in accordance with NFPA 14 and 24.

B. Install wafer check valve with ball drip valve at each fire department connection. Install concrete or cast iron vault set on #57 washed stone at wafer check valve.

C. Orient nozzle of FDC toward vehicle travel way.

D. Install signage out of pedestrian and vehicle travel ways near FDC. Front of sign to face primary vehicle travel way.

3.13 ALARM DEVICE INSTALLATION

A. Comply with NFPA 24 for devices and methods of valve supervision.

B. Supervisory Switches: Supervise valves in open position.

1. Valves: Grind away portion of exposed valve stem. Bolt switch, with plunger in stem depression, to OS&Y gate-valve yoke.
2. Indicator Posts: Drill and thread hole in upper-barrel section at target plate. Install switch, with toggle against target plate, on barrel of indicator post.

C. Connect alarm devices to building fire alarm system. Wiring and fire-alarm devices are specified in Division 22.

3.14 IDENTIFICATION INSTALLATION

A. Marking Tape: Marking tape shall be installed continuously and longitudinally along all water mains and water services for new construction and for any repair or retrofit construction using open trench methods. For service connections, the marking tape shall extend from the main line to the water meter. Marking tape shall be installed directly above the center of the pipe and at least 16-inches deep from final grade to a maximum depth of 24-inches below final grade.

B. Tracer Wire: Trace wire shall be installed in the same trench and inside bored holes and casing with pipe during pipe installation. It shall be secured to the pipe as required to insure that the wire remains adjacent to the pipe. The trace wire shall be securely bonded together at all wire joints with an approved watertight connector to provide electrical continuity, and it shall be accessible at all trace wire access points.

1. Except for approved spliced-in repair or replacement connections, tracer wire shall be continuous and without splices from each trace wire access point. Trace wire access points shall be accessible at all new water valve boxes, water meter boxes, blow-offs, ARVs, fire hydrants, irrigation turnouts and access manholes. Concentrations of multiple proposed valves near pipe intersections, i.e. tees or crosses, may require more than one access point assembly in each concrete valve box collar. Trace wire access points shall be within public right-of-way or public utility easements.

2. If the spacing of valves and meters is greater than one-half mile, the trace wire shall be looped up in a 2" PVC pipe to be located at a right-of-way fence line or at a cross fence line, as applicable, for protection. A PVC cap shall be placed on the 2" pipe when used, but it shall not be solvent welded onto the pipe.
3. At the point of connection between ductile iron water mains, with any non-iron water main, the tracer wire shall be properly connected to the iron pipe with a cad weld or approved equivalent. Tracer wire welds shall be completely sealed with the use of an approved mastic type sealer specifically manufactured for underground use. Mastic shall be applied in a thick coat a minimum of one quarter inch thick and shall be protected from contamination by the backfill material with the use of a plastic membrane.
4. Tracer wire shall be laid flat and securely affixed to the pipe at 10 foot intervals. The wire shall be protected from damage during the execution of the works. No breaks or cuts in the tracer wire or tracer wire insulation shall be permitted. At water service saddles, the tracer wire shall not be allowed to be placed between the saddle and the water main.
5. At all water main end caps, a minimum of 6 feet of tracer wire shall be extended beyond the end of the pipe, coiled and secured to the cap for future connections. The end of the tracer wire shall be spliced to the wire of a six pound zinc anode and is to be buried at the same elevations as the water main.

3.15 FIELD QUALITY CONTROL

A. All tests shall be performed in coordination with the project engineer and a City of Goldsboro Inspector.

B. Only potable water shall be used.

C. Hydrostatic Tests: Test at not less than 200-psi for 2 hours.

1. A section of line that is to be hydrostatically tested, shall be slowly filled with water at a rate which will allow complete evacuation of air from the line. Hand pumps shall not be used for the pressure testing of water mains. Taps used for testing purposes shall be removed after testing and repaired using a "no lead" brass plug.
2. When filling the pipeline, it is very important to fill the line slowly to avoid undue impacts associated with surge and to allow air to evacuate the pipeline. After all air has been expelled from the water main, the line shall be tested to a pressure of 150 psi as measured at the lowest elevation of the line for a duration of 2 hours. The testing period shall not commence until all air has been evacuated and the pressure has stabilized. The pressure gauge used in the hydrostatic test shall be calibrated in increments of 10-psi or less. The pressure gauge shall be liquid-filled and indexed for an operating range of 300-psi or less with a minimum dial size of 4 inches. At the end of the test period, the leakage shall be measured with an accurate water meter.
3. Any measured leakage not within the allowable limits as specified in the following table shall require repair of the water main and additional testing until the standards are met. For pipe sizes other than those shown, the Contractor shall test within the allowable leakage amounts as specified by AWWA C600-99. All visible leaks shall be repaired regardless of the amount of leakage.

Pipe Size (in)	Allowable Leakage at 200-psi (gal/hr per 1,000-ft of pipe)
4	0.38
6	0.57
8	0.76
10	0.96
12	1.15

D. Private Fire Service System Flushing & Testing: Perform flushing and all tests as required by NFPA 14 and NFPA 24. Contractor is responsible for performing and coordinating fire system installation and testing in accordance with the requirements of the City of Goldsboro.

1. Complete and submit "Contractor's Material and Test Certificate for Underground Piping" (NFPA 14) upon satisfactory completion of system flushing and all tests.

E. Disinfection: All additions or replacements to the water system shall be disinfected with chlorine in conformance with AWWA C651 before being placed in service under the supervision of the City's designated inspector in the following manner:

1. Taps shall be made at the control valve at the upstream end of the line and at all extremities of the line including valves.
2. solution of water containing 70% High Test Hypochlorite (HTH) available chlorine shall be introduced into the line by regulated pumping at the control-valve tap. The solution shall be of such a concentration that the line shall have a uniform concentration of not less than 50-ppm and not more than 100-ppm total chlorine immediately after chlorination. The chart below shows the required quantity of 70% HTH compound to be contained in solution in each 1000 feet section of line to produce the desired concentration from 50-ppm to100 ppm.

Pipe Size (in)	Lbs. of HTH (70%) Per 1000-ft of Pipe 50-ppm	Lbs. of HTH (70%) Per 1000-ft of Pipe 100-ppm
6	0.88	1.76
8	1.56	3.12
10	2.42	4.84
12	3.50	7.00
14	4.76	9.52
16	6.22	12.44
20	9.76	19.52

3. The HTH Solution shall be circulated in the main by opening the control valve and systematically manipulating hydrants and taps at the line extremities. The HTH solution must be pumped in at a constant rate for each discharge rate so a uniform concentration will be produced in mains.
4. HTH solution shall remain in lines for no less than 24 hours or as directed by the City's designated inspector.
5. Extreme care shall be exercised at all times to prevent the HTH solution from entering existing mains.
6. Free residual chlorine after 24 hours shall be at least 10 ppm or City will require that the lines be re-chlorinated.

F. Flushing: Flushing of lines may only proceed after 24 hours of disinfection contact time and as directed by City staff, provided the free residual chlorine analysis is satisfactory.

1. At the completion of disinfection, chlorinated water flushed from the water main shall be disposed of in conformance with all Federal, State and local regulations. In accordance with all applicable regulations, a neutralizing chemical shall be applied to minimize chlorine residual in the flushing water before discharging from the water main, unless an alternate plan is submitted in writing and approved by the City.
2. Water used for disinfection shall be flushed from the water main until the chlorine residual concentration is below 5-ppm before initiating sampling.

G. Bacteriological & Turbidity Sampling: The City of Goldsboro Public Water Treatment Plant will provide testing.

H. Tracer Wire Testing: Testing of the tracer wire and tape shall be performed by the Contractor at the completion of the project to assure they are all working properly in the presence of the City Inspector. It is the Contractor's responsibility to provide the necessary equipment to test the markers. Any defective, missing, or otherwise non-locatable units shall be replaced.

I. Backflow Prevention Device Certification

1. All new backflow prevention devices shall be tested and certified by an inspector approved by the City of Goldsboro prior to operation of the water system. Performance, coordination and submittal of documentation of the testing and certification shall be the responsibility of the Contractor.

J. Contractor shall be responsible for ensuring all waterlines are fully flushed and free of all deleterious matter prior to connecting to the building plumbing system.

END OF SECTION 331000

SECTION 333000 – SITE SANITARY SEWER UTILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes sewerage systems outside the building.

B. Related Sections: The following Sections contain requirements that relate to this Section.

1. Division 3 Section "Cast-in-Place Concrete" for cast-in-place concrete structures.

1.3 DEFINITIONS

A. Sewerage Piping: System of sewer pipe, fittings, and appurtenances for gravity flow of sanitary sewage.

1.4 PERFORMANCE REQUIREMENTS

A. Gravity-Flow, Nonpressure-Piping Pressure Ratings: At least equal to system test pressure.

1.5 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product data for the following:

1. Cleanouts.
2. Pipe and fittings.
3. Couplings.
4. Manhole Appurtenances.

C. Shop drawings for precast concrete manholes and other structures. Include frames, covers, and grates.

D. Shop drawings for cast-in-place concrete or field-erected masonry manholes and other structures. Include frames, covers, and grates.

E. As-Built survey of installed sanitary sewer mains and manholes. Perform and submit as-built survey as soon as possible following installation of manholes and sewer main piping. Survey shall be submitted at least 60-days prior to needed use of sewer main.

F. Record drawings at Project closeout of installed sanitary sewer system piping and products according to Division 1 Section "Closeout Procedures."

G. Inspection and test reports specified in the "Field Quality Control" Article.

1.6 QUALITY ASSURANCE

A. Environmental Agency Compliance: Comply with regulations pertaining to sanitary sewerage systems.

B. All materials, construction methods and testing shall comply with the requirements of the City of Goldsboro Engineering Department Specifications and Details Manual.

C. Product Options: Drawings indicate sizes, profiles, connections, and dimensional requirements of system components and are based on specific manufacturer types indicated. Other manufacturers' products with equal performance characteristics may be considered. Refer to Division 1 Section "Substitution Procedures."

D. As-Built Survey: As-built survey shall be signed and seal by a NC Professional Land Surveyor and shall include the following:

1. All manhole invert and rim elevations and horizontal locations with no less than two primary reference dimensions from permanent above grade features.
2. All cleanout locations with no less than two primary reference dimensions from permanent above grade features.
3. Pipe materials, sizes, lengths, and slopes.
4. Other sewer system components such as grease traps, etc.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic structures in direct sunlight.

B. Do not store plastic pipe or fittings in direct sunlight.

C. Protect pipe, pipe fittings, and seals from dirt and damage.

D. Handle precast concrete manholes and other structures according to manufacturer's rigging instructions.

1.8 PROJECT CONDITIONS

A. Site Information: Perform site survey, research public utility records, and verify existing utility locations.

B. Locate existing structures and piping to be closed and abandoned.

C. Existing Utilities: Do not interrupt existing utilities serving facilities occupied by the Owner or others except when permitted under the following conditions and then only after arranging to provide acceptable temporary utility services.

1. Notify Architect not less than 48 hours in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without receiving Architect's written permission.

1.9 SEQUENCING AND SCHEDULING

A. Coordinate sanitary sewerage system connections to municipality’s sanitary sewer.

B. Coordinate with interior building drainage systems.

C. Coordinate with other utility work.

PART 2 - PRODUCTS

2.1 PIPES AND FITTINGS

A. Ductile-Iron Pipe: AWWA C150 and C151, Pressure Class 350, for push-on joints per AWWA C111. Pipe shall be designed for an 8-foot minimum cover and a Type 1 laying condition.

1. Standard-Pattern, Ductile-Iron and Cast-Iron Fittings: AWWA C110, for push-on joints.
2. Compact-Pattern, Ductile-Iron Fittings: AWWA C153, for push-on joints.
3. Lining: AWWA C104, cement mortar, bituminous seal coated.
4. Gaskets: AWWA C111, rubber.

B. Polyvinyl Chloride (PVC) Sewer Pipe and Fittings: ASTM D 3034, SDR 35, for solvent-cemented or gasketed joints.

1. Primer: ASTM F 656.
2. Solvent Cement: ASTM D 2564.
3. Gaskets: ASTM F 477, elastomeric seal.

2.2 SPECIAL PIPE COUPLINGS AND FITTINGS

A. Sleeve-Type Pipe Couplings: Rubber or elastomeric sleeve and band assembly fabricated to match outside diameters of pipes to be joined, for nonpressure joints.

1. Sleeves for Cast-Iron Soil Pipe: ASTM C 564, rubber.
3. Sleeves for Plastic Pipe: ASTM F 477, elastomeric seal.
4. Sleeves for Dissimilar Pipes: Compatible with pipe materials being joined.
5. Bands: Stainless steel, at least one at each pipe insert.

B. Pipe to Manhole Connectors: ASTM C 923, resilient, water-tight flexible connector, of size required, for each pipe connecting to base section.

C. Sewer Service Saddles: PVC sewer pipe, saddles and adapters shall conform to the requirements of ASTM D 3034. Clamps shall be stainless steel. Saddles shall be installed in accordance with City of Goldsboro Engineering Department Specifications and Details Manual.

2.3 CLEANOUTS

A. Description: ASME A112.36.2M, round, cast-iron housing with clamping device and round, secured, scoriated, cast-iron cover. Include cast-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug. Use units with top-loading classifications according to the following applications:

1. Light Duty: In earth or grass, foot-traffic areas.
2. Medium Duty: In paved, foot-traffic areas.
3. Heavy Duty: In vehicle-traffic service areas.
4. Extra Heavy Duty: In roads.

B. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, service class, cast-iron soil pipe and fittings.

C. Cleanout Box: Cleanouts located in paved areas subject to vehicular traffic shall be protected by an 8-in diameter, ductile-iron cleanout box. ‘SEWER’ or ‘C.O.’ marking shall be cast into the lid.

2.4 MANHOLES

A. Precast Concrete Manholes: ASTM C 478, precast, internally coated, reinforced concrete, of depth indicated, with provision for rubber gasket joints.

1. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent floatation.
2. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and having a separate base slab or base section with integral floor.
3. Riser Sections: 4-inch minimum thickness, 48-inch diameter, and lengths to provide depth indicated.
4. Top Section: Eccentric cone type, unless concentric cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
5. Joints: 'O'-ring or plastic cement putty joint seal. 'O'-ring shall meet ASTM C443. Plastic cement putty shall meet Federal Spec SS-S210-A.
6. Grade Rings: Include 2 or 3 reinforced-concrete rings, of 6- to 9-inch total thickness, that match a 24-inch-diameter frame and cover.
7. Pipe Connectors: ASTM C 923, resilient, of size required, for each pipe connecting to base section.

B. Manhole Frames and Covers: ASTM A48, Class 35, gray iron. Include 22-1/4-inch inside diameter by 7-1/2-inch riser with 4-inch minimum width flange, and 23-1/2-inch- diameter cover with Cam Lock. Include indented top design with lettering, equivalent to the following, cast into cover:

1. Sanitary Sewerage Piping Systems: SANITARY SEWER - DANGER PERMIT REQUIRED - CONFINED SPACE DO NOT ENTER.

2.5 CONCRETE

A. General: Cast-in-place concrete according to ACI 318, ACI 350R, and the following:

1. Cement: ASTM C 150, Type II.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.
4. Water: Potable.

B. Structures: Portland-cement design mix, 4000 psi minimum, with 0.45 maximum water-cement ratio.

1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
2. Reinforcement Bars: ASTM A 615, Grade 60, deformed steel.

C. Structure Channels and Benches: Factory or field formed from concrete. Portland-cement design mix, 4000 psi minimum, with 0.45 maximum water-cement ratio.

2.6 IDENTIFICATION

A. Metallic-Lined Plastic Underground Warning Tapes: Polyethylene plastic tape with metallic core, 4 inches wide (min) by 4 mils thick, solid green in color with continuously printed caption in black letters "CAUTION - SEWER LINE BURIED BELOW."

B. Copper Tracer Wire: #12 gauge solid (bare) copper and continuous to the greatest extent possible. The tracer wire shall be securely bonded together at all wire joints with an approved industrial crimp connector to provide electrical continuity. Refer to City of Goldsboro Engineering Department Specifications and Details Manual for additional information and requirements.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.2 IDENTIFICATION

A. Install continuous plastic underground warning tape during back-filling of trench for underground sewer lines. Locate 6 inches to 8 inches below finished grade, directly over piping.

B. Install copper tracer wire during back-filling of trench for all sewer mains and service lines, complete with all required test ports, in accordance with City of Goldsboro standards. Perform continuity tests on all installed tracer wire in the presence of a City inspector. Repair or replace any failed segments.

3.3 INSTALLATION, GENERAL

A. General Locations and Arrangements: Drawings (plans and details) indicate the general location and arrangement of underground sewerage piping. Location and arrangement of piping layout take into account many design considerations. Install piping as indicated, to extent practical.

B. Install piping beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's recommendations for use of lubricants, cements, and other installation requirements. Maintain swab or drag in line and pull past each joint as it is completed.

C. Use manholes for changes in direction, except where fittings are indicated. Use fittings for branch connections, except where direct tap into existing sewer is indicated.

D. Use proper size increasers, reducers, and couplings, where different sizes or materials of pipes and fittings are connected. Reduction of the size of piping in the direction of flow is prohibited.

E. Install gravity-flow-systems piping at constant slope between points and elevations indicated. Install straight piping runs at constant slope, not less than that specified, where slope is not indicated.

F. Extend sewerage piping and connect to building's sanitary drains, of sizes and in locations indicated. Terminate piping as indicated.

G. Install sewerage piping pitched down in direction of flow, at minimum and cover as indicated.

H. Tunneling: Install pipe under streets or other obstructions, which cannot be disturbed, by tunneling, jacking, or a combination of both.

I. Core-drill manhole and install flexible pipe-to-manhole connector to connect sewer service pipe to manhole per manufacturer’s instructions.

3.4 PIPE JOINT CONSTRUCTION AND INSTALLATION

A. General: Join and install pipe and fittings according to the following.

B. Ductile-Iron Pipe with Ductile-Iron or Cast-Iron Fittings: With push-on-joint, rubber gaskets according to AWWA C600.

C. Polyvinyl Chloride (PVC) Plastic Pipe and Fittings: As follows:

1. Join solvent-cement-joint pipe and fittings with solvent cement according to ASTM D 2855 and ASTM F 402.
2. Join pipe and gasketed fittings with elastomeric seals according to ASTM D 2321.
3. Join profile sewer pipe and ribbed drain pipe and gasketed fittings with elastomeric seals according to ASTM D 2321 and manufacturer's written instruction.
4. Install according to ASTM D 2321.

3.5 MANHOLE INSTALLATION

A. General: Install manholes, complete with accessories, as indicated.

B. Form continuous concrete channels and benches between inlets and outlet, where indicated.

C. Set tops of frames and covers flush with finished surface where manholes occur in pavements. Set tops 3 inches above finished surface elsewhere, except where otherwise indicated.

D. Place precast concrete manhole sections as indicated and install according to ASTM C 891.

1. Provide joint gasket at joints of sections.
2. Apply bituminous mastic coating at joints of sections.

E. Apply protective coating consisting of one primer coat, one intermediate coat and one top coat with brush, spray, or roller.

3.6 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 318, ACI 350R, and as indicated.

3.7 CLEANOUT INSTALLATION

A. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.

B. Set cleanout frames and covers in earth in a cast-in-place concrete block, 18 by 18 by 12 inches deep. Set with tops 1 inch above surrounding earth grade. Precast cleanout collars shall not be used.

C. In Paved Areas: Cleanouts shall be installed within a protective cleanout box set flush with surface of paving.

3.8 FIELD QUALITY CONTROL

A. Clear interior of piping and structures of dirt and superfluous material as the work progresses. Maintain swab or drag in piping and pull past each joint as it is completed.

1. In large, accessible piping, brushes and brooms may be used for cleaning.
2. Place plug in end of incomplete piping at end of day and whenever work stops.
3. Flush piping between manholes and other structures, if required by authorities having jurisdiction, to remove collected debris.

B. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of the Project.

1. Submit separate reports for each system inspection.

2. Defects requiring correction include the following:

    a. Alignment: Less than full diameter of inside of pipe is visual between structures.
    b. Deflection: Flexible piping with deflection that prevents passage of a ball or cylinder of a size not less than 92.5 percent of piping diameter.
    c. Crushed, broken, cracked, or otherwise damaged piping.
    d. Infiltration: Water leakage into piping.
    e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

C. Test new piping systems and parts of existing systems that have been altered, extended, or repaired for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to authorities having jurisdiction.
3. Schedule tests, and their inspections by the City of Goldsboro, with at least 24 hours advance notice.
4. Submit separate reports for each test.
5. Perform hydrostatic test or low pressure air test as required by the City of Goldsboro Engineering Department Specifications and Details Manual.

    a. Hydrostatic test: Allowable leakage is a maximum of 100 gallons per inch nominal pipe size per mile of pipe per 24-hours.
    b. Air test: Perform air test according to ASTM C828.

6. Manholes: Perform vacuum test according to ASTM C 1244.
7. Leaks and loss in test pressure constitute defects that must be repaired.
8. Replace leaking piping using new materials and repeat testing until leakage is within allowances specified.

END OF SECTION 333000

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SECTION 334000 - SITE STORM DRAINAGE UTILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes site drainage systems outside the building. Systems include the following:

1. Storm drainage.
2. Foundation drainage connections outside of building.
3. Roof drainage connections outside of building.

B. Related Sections: The following Sections contain requirements that relate to this Section.

1. Division 31 Section “Earth Moving.”
2. Division 31 Section “Sediment and Erosion Controls.”
3. Division 3 Section “Cast-In-Place Concrete.”
4. Division 22 Sections for storm drainage inside the building.

1.3 DEFINITIONS

A. Drainage Piping: System of pipe, fittings, and appurtenances for gravity flow of storm drainage.

1.4 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. As-Built Survey / Record drawings of installed drainage system piping and basins and all stormwater management devices (ponds, wetlands, bio-retention areas). Survey shall be submitted as soon as possible and at least 30-days prior to the project’s substantial completion.

1.5 QUALITY ASSURANCE

A. Environmental Agency Compliance: Comply with regulations pertaining to storm drainage systems.

B. Utility Compliance: Comply with regulations pertaining to storm drainage systems.

C. Product Options: Drawings indicate sizes, profiles, connections, and dimensional requirements of system components and are based on specific manufacturer types indicated. Other manufacturers' products with equal performance characteristics may be considered. Refer to Division 1 Section "Products."

D. All work within any NCDOT right-of-way shall conform to the requirements of the current version of the NCDOT’s Policies and Procedures for Accommodating Utilities on Highway Rights of Way, the provisions and conditions of the encroachment agreement(s), and other applicable NCDOT standards and policies. The encroachment agreement(s) are considered part of the project specifications by reference. Copies of the agreement(s) will be provided upon request from the Architect.

E. Perform As-Built Survey of installed drainage system piping and basins and all stormwater management devices (ponds, wetlands, bio-retention areas). As-built survey shall be signed and seal by a NC Professional Land Surveyor and shall include the following:

1. All inlet, junction box and manhole locations with no less than two primary reference dimensions from permanent above grade features.
2. As-built rims and inverts noted.
3. Pipe materials and sizes, plus slopes and distances between structures.
4. As-built dimensions for installed riprap dissipater pads.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic structures in direct sunlight.

B. Do not store plastic pipe or fittings in direct sunlight.

C. Protect pipe, pipe fittings, and seals from dirt and damage.

1.7 PROJECT CONDITIONS

A. Site Information: Perform site survey, research public utility records, and verify existing utility locations.

B. Locate existing structures and piping to be closed and abandoned.

C. Existing Utilities: Do not interrupt existing utilities serving facilities occupied by the Owner or others except when permitted under the following conditions and then only after arranging to provide acceptable temporary utility services.

1. Notify Architect not less than 48 hours in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without receiving Architect's written permission.

1.8 SEQUENCING AND SCHEDULING

A. Coordinate storm drainage system connections to utility company's storm sewer.

B. Coordinate storm drainage system connections to existing on-site storm sewer.

C. Coordinate with interior building drainage systems.

D. Coordinate with other utility work.

PART 2 - PRODUCTS

2.1 PIPES AND FITTINGS

A. General: Refer to plans for specific pipe material applications.

B. Ductile-Iron Pipe: ANSI/AWWA C150/A21.50 and C151/A21.51, minimum pressure class 250.

1. Lining: AWWA C104, cement mortar, coal tar expoxy lined.
2. Gaskets, Glands, and Bolts and Nuts: AWWA C111.
3. Push-On-Joint-Type Pipe: AWWA C111, rubber gaskets.
4. Coating: AWWA C151, bituminous coating.

C. Polyvinyl Chloride (PVC) Sewer Pipe and Fittings: ASTM D-1785, SCH 40 PVC for solvent-cemented or gasketed joints.

1. Primer: ASTM F 656.
2. Solvent Cement: ASTM D 2564.
3. Gaskets: ASTM F 477, elastomeric seal.

D. Reinforced-Concrete Sewer Pipe and Flared End Sections: ASTM C 76, Class III. Provide Class IV where noted on the drawings.

1. Standard Joints: Plastic cement putty seal meeting ASTM C990 and Federal Specification SS-S-00210.
2. Watertight Joints: O-ring rubber gasket meeting ASTM C-443 with external sealer wrap that is at least 12 inches wide and covers the full circumference of the joint.
   a. External wrap shall be ConWrap CS-212 from Concrete Sealants, Inc., EZ-Wrap form Press-Seal Gasket Corp., Seal Wrap from Mar-Mac Manufacturing or approved equal. Cover external joint sealer with a 3 foot strip of filter fabric meeting NCDOT Type 4 Engineering Fabrics.
   b. Watertight joints shall be provided at outlet pipes that penetrate pond embankments and other locations specified on the drawings.

2.2 FOUNDATION DRAIN PIPING

A. Storm Foundation-Drain Pipe and Fittings: SCH 40 PVC with ½-in drilled perforations. Minimum 4-inch diameter unless otherwise indicated on the drawings. Non perforated PVC pipe shall be used to connect foundation drains to drainage inlets.

B. Filter Fabric: Woven geotextile Drainage (Filter) Fabric as specified in Division 31 Section “Earth Moving.”

2.3 SPECIAL PIPE COUPLINGS AND FITTINGS

A. Connection from roof downspout to underground storm pipe.

1. Vertical stainless-steel downspout adapter with sch. 40 PVC pipe outlet sized to fit over downspout and underground piping. Adapter shall have a self-cleaning debris trap consisting of a hinged cover and removable debris screen. Powder-coat color to be selected by Architect from manufacturer’s full range of colors. As manufactured by Piedmont Pipe Construction.
2. Manufactured fitting of material similar to downspout sized to connect to standard round pipe shape of underground piping.

2.4 DROP INLETS, CATCH BASINS AND CONDENSATE RELIEF BASINS

A. General: Brick and mortar or precast concrete, of depth, shape, and dimensions indicated. Knock-out “waffle” boxes shall not be used. All structures shall be designed to withstand AASHTO HS-20 loads and meet NCDOT standards.

B. Brick Inlets: Brick and mortar or precast concrete, of depth, shape, and dimensions indicated.

1. Base, Channel, and Bench: Concrete.
2. Wall: ASTM C 32, Grade MS, clay brick masonry units.

a. Option: ASTM C 55, Grade S-II, solid concrete brick masonry units may be used instead of clay brick.

3. Mortar: ASTM C 270, Type S, using ASTM C 150, Type I, portland cement.

C. Precast Concrete Inlets: ASTM C913, precast, reinforced concrete, of depth, shape, and dimensions indicated designed for HS-20 loading. Precast boxes shall include grade rings to allow adjustment to rim elevations. Knock-out waffle boxes shall not be used.

1. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
2. Riser Sections: 4-inch minimum thickness and lengths to provide depth indicated.
3. Top Section: Flat-slab-top type is indicated.
4. Joint Sealant: ASTM C990, bitumen or butyl rubber.
5. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.
6. Grade Rings: Include two or three reinforced-concrete rings, of 6- to 9-inch total thickness to allow field adjustment of rim elevation.

D. Steps: Individual FRP steps or deformed, 1/2-inch steel reinforcing rods encased in polypropylene plastic, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of catch basin to finished grade is less than 42 inches.

E. Pipe Connectors: ASTM C923, resilient, of size required, for each pipe connecting to base section.

F. Flat Frames and Grates: ASTM A48, Class 35B, cast iron, H-20 loading. Include flat grate with small square or short-slotted drainage openings as indicated on the drawings.

1. Provide drop inlet grates with openings compliant with ADA standards when located within sidewalk or other pedestrian walking areas and/or where specifically indicated on drawings.

G. Catch Basin Hood Casting: ASTM A48, Class 35B, cast iron, H-20 loading.

2.5 IN-LINE DRAINS

A. In-Line Drains: 12-inch ductile iron drain designed to be attached with a watertight connection to vertical 12-inch PVC pipe, slotted surface grate of shape indicated on the drawings, watertight pipe adapters. Grates shall be pedestrian-type where set in pavement or sidewalk and dome-type where set in mulched areas.

2.6 MANHOLES

A. Precast Concrete Storm Drainage Manholes: ASTM C-478 precast reinforced concrete, eccentric cone. All structures shall be designed to withstand AASHTO H-20 loads.

1. Base, Channel, and Bench: Concrete.
2. Joint: Preformed flexible plastic gaskets complying with Fed. Spec. SS-S-210A.
3. Size: As required to accommodate proposed pipes indicated on the drawings, 4-ft diameter minimum.

B. Frames and Covers: ASTM A48, Class 35B, heavy-duty cast iron. Include flat, round grate with 1-1/2” wide slotted drainage openings with a minimum total open area of 150-sq.in.

2.7 STORMWATER CONTROL MEASURE OUTLET STRUCTURE

A. Brick or Block Outlet Structure: Brick and mortar, of depth, shape, and dimensions indicated. All structures shall be designed to withstand AASHTO H-20 loads.

1. Base and ballast in-fill: Concrete.
2. Wall: ASTM C 32, Grade MS, clay brick masonry units or ASTM C 55, Grade S-II, solid concrete brick masonry unit.
3. Mortar: ASTM C 270, Type S, using ASTM C 150, Type I, portland cement.
4. Grout for Pond/Wetland/SCM Installations: ASTM C1107, non-shrink, hydraulic cement grout.
5. Interior and Exterior Coatings: Cement-based waterproof coating base coat with tintable, non-toxic epoxy finish coat formulated for immersion in water meeting NSF/ANSI 61 for potable water.
   a. Cement Coating: BASF MasterSeal 581 or approved equal.
   b. Epoxy Coating: Pond Armor Pond Shield Epoxy Waterproof Pond Sealant or approved equal.
   c. Colors to be selected by designer from manufacturer's standard colors.

B. Concrete Outlet Structure: Pre-Cast, solid wall, 4,000-psi, reinforced concrete designed to meet H-20 loading of depth, shape, and dimensions indicated. Waffle boxes are not acceptable.

1. Base and ballast in-fill: Concrete.
2. Wall: Solid, reinforced concrete. Provide exterior brick veneer if indicated on drawings.
   a. Brick: ASTM C 32, Grade MS, clay brick units.
   b. Mortar: ASTM C 270, Type S, using ASTM C 150, Type I, portland cement.

3. Joints: Pre-Cast structures shall have no section joints below permanent pool elevation.
4. Grout: ASTM C1107, non-shrink, hydraulic cement grout.
5. Interior and Exterior Coatings: Cement-based waterproof coating base coat with tintable, non-toxic epoxy finish coat formulated for immersion in water meeting NSF/ANSI 61 for potable water.
   a. Cement Coating: BASF MasterSeal 581 or approved equal.
   b. Epoxy Coating: Pond Armor Pond Shield Epoxy Waterproof Pond Sealant or approved equal.
   c. Colors to be selected by designer from manufacturer's standard colors.

C. Pipe Connectors: ASTM C 923, resilient, water-tight flexible connector, of size required, for each pipe connecting to outlet structure.

1. Following installation of pipe connector, grout voids between pipe, connector and outlets structure with non-shrink hydraulic cement grout on inside and outside of outlet structure. Finish grout flush with structure wall.

D. Frames and Grates: ASTM A48, Class 35B, cast iron, H-20 loading. Include flat grate with slotted drainage openings as indicated on the drawings.

E. Trash Rack: Aluminum with separate frame a grate with access hatch as detailed on the drawings. Trash racks shall be as manufactured by Trashracks.com or approved equal.

2.8 CLEANOUTS

A. Description: ASME A112.36.2M, round, cast-iron housing with clamping device and round, secured, scoriated, cast-iron cover. Include cast-iron ferrule with inside calk or spigot connection and

countersunk, tapered-thread, brass closure plug. Cleanout shall be rated for “heavy duty” top-loading classifications.

1. Cleanout Box: Cleanouts located in paved areas subject to vehicular traffic shall be protected by an 8-in diameter, ductile-iron cleanout box. ‘STORM’ marking shall be cast into the lid.

2.9 CONCRETE

A. General: Cast-in-place concrete according to ACI 318, ACI 350R, and the following:

1. Cement: ASTM C 150, Type I, 3,000-psi.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.
4. Water: Potable.

B. Structures: Portland-cement design mix, 4000 psi minimum, with 0.45 maximum water-cement ratio.

1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
2. Reinforcement Bars: ASTM A 615, Grade 60, deformed steel.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.2 SPECIAL PIPE COUPLING AND FITTING APPLICATIONS

A. Special Pipe Couplings: Use where indicated and where required to join piping and no other appropriate method is specified. Do not use instead of specified joining methods.

3.3 INSTALLATION, GENERAL

A. General Locations and Arrangements: Drawings (plans and details) indicate the general location and arrangement of underground drainage systems piping. Location and arrangement of piping layout take into account many design considerations. Install piping as indicated, to extent practical. Refer to drawings for material and structure types for specific applications.

1. Orient grates of drainage structures in paved areas to align with general pattern of pavement joints and scoring.

B. Install piping beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's recommendations for use of lubricants, cements, and other installation requirements. Maintain swab or drag in line and pull past each joint as it is completed.

C. Use proper size increasers, reducers, and couplings, where different sizes or materials of pipes and fittings are connected. Reduction of the size of piping in the direction of flow is prohibited.

D. Extend drainage piping and connect to building's storm drains, of sizes and in locations indicated. Terminate piping as indicated.

E. Install drainage piping pitched down in direction of flow, at minimum slope of 1 percent and 36-inch minimum cover, except where otherwise indicated.

F. Polyvinyl Chloride (PVC) Plastic Pipe and Fittings: As follows:

1. Join solvent-cement-joint pipe and fittings with solvent cement according to ASTM D 2855 and ASTM F 402.
2. Join pipe and gasketed fittings with elastomeric seals according to ASTM D 2321.
3. Join profile sewer pipe and ribbed drain pipe and gasketed fittings with elastomeric seals according to ASTM D 2321 and manufacturer's written instruction.
4. Install according to ASTM D 2321.

G. Join piping made of different materials or dimensions with couplings made for this application. Use couplings that are compatible with and fit both systems' materials and dimensions.

H. Install stormwater control measure outlet pipes through embankments with concrete support cradle from the bottom of the pipe trench to the springline of the pipe.

3.4 CATCH BASIN AND DROP INLET INSTALLATION

A. Construct inlets to sizes and shapes indicated.

B. Set frames and grates to elevations indicated.

C. Install prefabricated area drains per manufacturer’s instructions.

3.5 STORMWATER TREATMENT DEVICE INSTALLATION

A. Install in accordance with the site plans and the manufacturer’s detail drawings and installation instructions. Install device on a base of 8-in thick aggregate base course over compacted subgrade.

B. Test device for water tightness prior to backfilling.

3.6 CLEANOUT INSTALLATION

A. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Install piping so cleanouts open in direction of flow in sewer pipe.

B. In Paved Areas: Cleanouts shall be installed within a protective cleanout box set flush with surface of paving.

C. In Non-Paved Areas: Set cleanout tops 1 inch above surrounding earth grade.

3.7 CLOSING ABANDONED STORM DRAINAGE SYSTEMS

A. Abandoned Piping: Close open ends of abandoned underground piping that is indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either of the following procedures:

1. Close open ends of piping with at least 8-inch-thick brick masonry bulkheads.
2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.

B. Abandoned Structures: Excavate around structure as required and use either of the following procedures:

1. Remove structure and close open ends of remaining piping.

2. Backfill to grade according to Division 31 Section "Earth Moving."

3.8 FIELD QUALITY CONTROL

A. Clear interior of piping and structures of dirt and superfluous material as the work progresses. Maintain swab or drag in piping and pull past each joint as it is completed.

1. In large, accessible piping, brushes and brooms may be used for cleaning.
2. Place plug in end of incomplete piping at end of day and whenever work stops.
3. Flush piping between manholes and other structures, if required by authorities having jurisdiction, to remove collected debris.

B. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of the Project.

1. Submit separate reports for each system inspection.
2. Defects requiring correction include the following:

a. Alignment: Less than full diameter of inside of pipe is visual between structures.
b. Deflection: Flexible piping with deflection that prevents passage of a ball or cylinder of a size not less than 92.5 percent of piping diameter.
c. Crushed, broken, cracked, or otherwise damaged piping.
d. Infiltration: Water leakage into piping.
e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

C. Test new piping systems and parts of existing systems that have been altered, extended, or repaired for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to authorities having jurisdiction.
3. Schedule tests, and their inspections by authorities having jurisdiction, with at least 24 hours' advance notice.
4. Submit separate reports for each test.

END OF SECTION 334000

SECTION 334600 - SUBDRAINAGE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Perforated-wall pipe and fittings.
2. Sock-style pipe filter covers

B. Related Requirements
1. Refer to Section 071113 “Bituminous Damproofing” for drainage panels

1.2 ACTION SUBMITTALS

A. Product Data:
1. Sock-style pipe filter covers

PART 2 - PRODUCTS

2.1 PERFORATED-WALL PIPES AND FITTINGS

A. Perforated PE Pipe and Fittings:

1. NPS 6 (DN 150) and Smaller: ASTM F405 or AASHTO M 252, Type CP; corrugated, for coupled joints.
2. NPS 8 (DN 200) and Larger: ASTM F667; AASHTO M 252, Type CP; or AASHTO M 294, Type CP; corrugated; for coupled joints.
3. Couplings: Manufacturer's standard, band type.

B. Perforated PVC Sewer Pipe and Fittings: ASTM D2729, bell-and-spigot ends, for loose joints.

C. Sock-Style pipe filter covers: ASTM D6707-06 for circular-knit geotextile fabric for use in subsurface drainage applications
1. Puncture resistance: minimum 800N
2. Apparent Opening size: No. 40 (0.425-mm) maximum
3. Carriff Drainage Filter Socks or equal from other manufacturer

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and areas for suitable conditions where subdrainage systems are to be installed.

B. If subdrainage is required for landscaping, locate and mark existing utilities, underground structures, and aboveground obstructions before beginning installation and avoid disruption and damage of services.

C. Verify that drainage panels installed as part of foundation wall waterproofing is properly positioned to drain into subdrainage system.

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

3.2 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.3 FOUNDATION DRAINAGE INSTALLATION

A. Place impervious fill material on subgrade adjacent to bottom of footing after concrete footing forms have been removed. Place and compact impervious fill to dimensions indicated, but not less than 6 inches (150 mm) deep and 12 inches (300 mm) wide.

B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.

C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).

D. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape per manufacturer instructions.

E. Install drainage piping as indicated in Part 3 "Piping Installation" Article for foundation subdrainage.

F. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.

G. After satisfactory testing, cover drainage piping to width of at least 6 inches (150 mm) on side away from footing and above top of pipe to within 12 inches (300 mm) of finish grade.

H. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.

I. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 inches (100 mm).

J. Install drainage panels on foundation walls as follows:

1. Coordinate placement with other drainage materials.
2. Lay perforated drainage pipe at base of footing. Install as indicated in Part 3 "Piping Installation" Article.
3. Separate 4 inches (100 mm) of fabric at beginning of roll and cut away 4 inches (100 mm) of core. Wrap fabric around end of remaining core.
4. Attach panels to wall beginning at subdrainage pipe. Place and secure molded-sheet drainage panels, with geotextile facing away from wall.

K. Place backfill material over compacted drainage course. Place material in loose-depth layers not exceeding 6 inches (150 mm). Thoroughly compact each layer. Final backfill to finish elevations and slope away from building.

3.4 PIPING INSTALLATION

A. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves, and couplings in accordance with manufacturer's written instructions and other requirements indicated.

1. Foundation Subdrainage: Install piping level and with a minimum cover of 36 inches (915 mm) unless otherwise indicated.
2. Lay perforated pipe with perforations down.
3. Excavate recesses in trench bottom for bell ends of pipe. Lay pipe with bells facing upslope and with spigot end entered fully into adjacent bell.

B. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.

C. Install thermoplastic piping in accordance with ASTM D2321.

3.5 PIPE JOINT CONSTRUCTION

A. Join perforated PE pipe and fittings with couplings in accordance with ASTM D3212 with loose banded, coupled, or push-on joints.

B. Join perforated PVC sewer pipe and fittings in accordance with ASTM D3212 with loose bell-and-spigot, push-on joints.

C. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.

3.6 CLEANOUT INSTALLATION

A. Comply with requirements for cleanouts specified in Section 334100 "Storm Utility Drainage Piping."

B. Cleanouts for Foundation Subdrainage:

1. Install cleanouts from piping to grade. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
2. In vehicular-traffic areas, use NPS 4 (DN 100) cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 18 by 18 by 12 inches (450 by 450 by 300 mm) deep. Set top of cleanout flush with grade.
3. In nonvehicular-traffic areas, use NPS 4 (DN 100) PVC pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place

concrete anchor, 12 by 12 by 4 inches (300 by 300 by 100 mm) deep. Set top of cleanout 2 inches (50 mm) above grade.

4. Comply with requirements for concrete specified in Section 033000 "Cast-in-Place Concrete."

3.7 CONNECTIONS

A. Comply with requirements for piping specified in Section 334100 "Storm Utility Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect low elevations of subdrainage system to solid-wall-piping storm drainage system.

C. Where required, connect low elevations of foundation subdrainage to stormwater sump pumps. Comply with requirements for sump pumps specified in Section 221429 "Sump Pumps."

3.8 IDENTIFICATION

A. Arrange for installation of green warning tapes directly over piping. Comply with requirements for underground warning tapes specified in specified in Section 312000 "Earth Moving."

1. Install PE warning tape or detectable warning tape over ferrous piping.
2. Install detectable warning tape over nonferrous piping and over edges of underground structures.

3.9 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling.
2. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.

B. Drain piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 CLEANING

A. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

END OF SECTION 334600