

BALTIMORE COUNTY PUBLIC SCHOOLS
Division of Business Services; Department of Fiscal Services; Office of Purchasing
6901 Charles Street, Building "E", 1st Floor
Towson, Maryland 21204

SPECIFICATION AND PROPOSAL

FOR

REPLACEMENT OF VICTORY VILLA ELEMENTARY SCHOOL

VOLUME 2 (Div. 21-33; APPENDIX)

SOLICITATION NUMBER: **ARA-209-17 (PSCP#03.057.17 LPC)**

BID ISSUED DATE: **November 10, 2016**

PRE-BID: A PRE-BID meeting is scheduled for **November 16, 2016 at 3:00 P.M.**; at **BCPS Office of Engineering and Construction, 9610 Pulaski Park Drive, Suite 204 Baltimore, Maryland, 21220.**

DUE DATE: December 8, 2016

DUE TIME: **2:00 P.M.** (Eastern Time Zone)

RETURN TO: BALTIMORE COUNTY PUBLIC SCHOOLS
OFFICE OF PURCHASING
ARA-209-17 Attn: Anita Randall
6901 Charles Street, Building "E", 1st Floor
Towson, Maryland 21204

PUBLIC OPENING: Same date, (10 minutes after due time)
Conference Room
6901 Charles Street, Building "E", 1st Floor
Towson, Maryland 21204

Failure to plainly identify as a "SEALED BID" on the outside of the return envelope may result in premature opening of the envelope and bid.

Baltimore County Public Schools reserves the right to waive informalities, to reject all bids, and to reissue this bid at its option, and does not make an obligation to purchase by issuing this bid.

For updated bid information please call the "Bidder's Hotline" at 410-887-7819 or visit our website www.bcps.org/offices/purchasing/bidboard/

SECTION 210101 - FIRE-SUPPRESSION GENERAL PROVISIONS

PART 1 - GENERAL

1.11 SUMMARY

- A. General provisions and requirements for all fire-suppression work.

1.14 RELATED SECTIONS

- A. Requirements of this section generally supplement requirements of Division 01.
- B. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.

1.20 REFERENCES

- A. NFPA 10: Portable Fire Extinguishers.
- B. NFPA 241: Safeguarding Construction, Alteration, and Demolition Operations.

1.25 SYSTEM DESCRIPTION

- A. The full set of Contract Documents applies to work of Division 21.
- B. Visit the site and study all aspects of the project and working conditions, as required by General and Supplementary Conditions, Bidding and Contracting Requirements, Drawings, and Specifications. Verify field dimensions.
- C. The work covered in technical sections includes the furnishing of all labor, equipment and materials, and the performance of all operations pertinent to the work described.
- D. Except as required otherwise in Division 01, promptly obtain and pay for, including all necessary signatures and paperwork, all permits, fees and inspections required for work of this division by authorities having jurisdiction, including any utility connection or extension charge. No payment will be made until a copy of the permit is forwarded to the Owner.
- E. Fire-suppression work of this project includes, as a brief general description, the following:
 - 1. Provision of a new NFPA 13 compliant wet pipe sprinkler system to serve the entirety of the new building.
 - 2. The project includes commissioning under the direction of a Commissioning Agent (CxA).
 - 3. The project will be LEED certified.
- F. See Division 01 for requirements related to LEED certification, commissioning, limits on use of site, time restrictions on work, limits on utility outages or shutdowns, and phasing (sequencing) and scheduling.

1.26 PRODUCT OPTIONS

- A. Except as modified by provisions of Bidding and Contracting Requirements and Division 01, these options apply to Division 21 specifications.

- B. General: Where Contractor is permitted to use a product other than the specified item and model named as the basis of design, Contractor is responsible for all coordination and additional costs as specified in the article "Substitutions," below for substitutions.
- C. Products specified by reference standards or by description only: Any product meeting those standards or description.
- D. Products specified by naming one or more manufacturers, or model name or catalog reference number: Products specified establish a standard of quality, options to be included, and performance.
 - 1. Where other acceptable manufacturers are named, Contractor may provide products of those named manufacturers only, which meet the specifications.
 - 2. Where specification permits "equal" products, without naming other acceptable manufacturers, Contractor may use products of any manufacturer, which meet the specifications.
- E. Products specified by naming one manufacturer and particular product, with no provision for other options: No options or substitutions allowed.

1.27 SUBSTITUTIONS

- A. Substitutions will be considered only as permitted or required by the Bidding and Contracting Requirements and Division 01. Except as modified by those requirements, the requirements below apply to Division 21 specifications.
- B. Substitutions may be considered when a product becomes unavailable through no fault of the Contractor.
- C. Document each request with complete data substantiating compliance of proposed substitution with contract documents.
- D. A request constitutes a representation that the Bidder or Contractor:
 - 1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product.
 - 2. Will provide the same warranty for the substitution as for the specified product.
 - 3. Will coordinate installation and make changes to other work which may be required for the work to be complete with no additional cost to Owner.
 - 4. Waives claims for additional costs or time extension which may subsequently become apparent.
 - 5. Will reimburse Owner for review or redesign services associated with re-approval by authorities.
- E. Substitutions will not be considered when they are indicated or implied on shop drawing or product data submittals, without separate written request, or when acceptance will require revision to the Contract Documents.
- F. Substitution submittal procedure is specified in Bidding and Contracting Requirements and Division 01.

1.28 MATERIALS AND EQUIPMENT

- A. All materials and equipment shall be new and the best of their respective kinds, suitable for the conditions and duties imposed on them by the project and of representative manufacture. The description, characteristics and requirements of the materials to be used shall be in accordance with the specifications.
- B. All equipment, construction and installation must meet requirements of local, state and federal governing codes.
- C. Singular number: In cases where material, a device, or part of the equipment is referred to in the singular number in the specifications, it is intended that such reference shall apply to as many items of material, devices, or parts of the equipment as are required to complete the installation as shown on the drawings or required for proper operation of the system.
- D. Terms have the following meanings:
 - 1. Furnish: Supply item
 - 2. Install: Mount and connect item
 - 3. Provide: Furnish and install.
- E. All materials and equipment shall be installed and completed in a first class and workmanlike manner and in accordance with the best modern methods, practice and manufacturers' instructions. Any work which shall not present an orderly and neat or workmanlike appearance shall be removed and replaced with satisfactory work when so directed in writing by the Architect.
- F. The specifications and drawings are intended to define the minimum requirements, as to quality of materials, construction, finish and overall workmanship.
- G. General Conditions describe the correlation and intent of the Contract Documents. In case of discrepancies between the specifications and drawings, the specifications should be followed as to the general methods and principles and the drawings followed as to sizes, capacities and specifics for corresponding parts. If sizes are omitted, the Architect will determine sizes to be utilized.
- H. In all cases of doubt, uncertainty, or conflict as to the true meaning of the specifications or drawings, it is the responsibility of the Contractor to notify the Architect of said uncertainty, doubt, or conflict and obtain a decision as to the intent before starting any work which may be affected by this decision.

1.29 COORDINATION

- A. Should a situation develop during construction to prevent the proper installation of any equipment or item where shown on the drawings, call the situation to the attention of the Architect and await a written decision.
- B. Plan and coordinate all work to proceed in an orderly and continuous manner without undue delay, and in conformance with project schedule. Submit samples, shop drawings, schedules, insurance policies and certificates, and the like in time to avoid delays in actual construction. Coordinate work so that work of each trade is completed before other construction begins which would obstruct it.
- C. Coordinate trades to ensure that proper clearances between work of the various trades allow access to items which require operation and maintenance.

- D. Coordinate location and elevation of all piping, equipment, and appurtenances in such a manner that the finished installation is as indicated on drawings. In the event difficulties are encountered which prevent this, it is the Contractor's responsibility to bring this to the attention of the Architect prior to initiation of work. Correct improperly coordinated installation at no additional cost.
- E. The Contractor's assistants shall include a competent mechanical foreman, who shall be on the premises at all times to check, layout, coordinate and superintend the installation of work. The foreman shall establish all grades and lines relative to the work before starting, and be responsible for the accuracy thereof.

1.30 SUBMITTALS

A. Manufacturers' and subcontractors' lists:

- 1. As specified in Division 01, submit a complete list of proposed manufacturers for all equipment, materials and subcontractors used for the work of this division. Lists shall follow the sequence of the specifications. No considerations will be given for partial or incomplete lists. After review of lists, submit shop drawings and product data.

B. Shop drawings and product data:

- 1. Submit in accordance with the requirements of Division 01 or as established at the preconstruction conference, the required number of copies of shop drawings and product data for every item of equipment. Shop drawings or product data will not be considered until manufacturers' lists have been approved. Shop drawings and product data shall be submitted, as required by the General Conditions, with sufficient time for checking, return to Contractor, and resubmission as required before Contractor shall install any item.
- 2. Each item submitted shall be properly labeled, indicating the specific service for which the equipment or material is to be used, section and paragraph number of specification or drawing number to which it applies, Contractor's name and project name and number. Data submitted shall be specific and shall include product data and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents. Clearly identify each item within the data. Data of a general nature will not be accepted. Each sheet must clearly show the project name and number.
- 3. The review of a shop drawing or product data shall not be considered as a guarantee of the measurements or building conditions or that the shop drawings or product data have been checked to see that item submitted properly fits the building conditions. This review shall not relieve the Contractor of the responsibility for furnishing material or performing work as required by the contract documents, for correctness of dimensions and quantities, or for proper coordination of details and interfaces among trades.
- 4. All exclusively electrical items furnished as items associated with fire-suppression items but not specifically described in the fire-suppression item submission, shall be submitted as a separate submittal but shall be clearly marked as associated with the fire-suppression item by identification specification paragraph.
- 5. Product data sheets shall be 8.5-inches by 11-inches cut sheets for operating and maintenance manual.

C. Submit at least three copies of the results of every test required under any section in this division.

D. Specialist shall submit a list of at least three projects similar to this project in type, size, and quality, which have been in place and operating satisfactorily for at least five years.

1. Include project name, address, name and phone number of owner's representative, and project type and size.

E. After the work is completed, submit all required certificates of approval from approved inspection agencies and authorities having jurisdiction over work of this division. Certificates of approval must be received by the Architect prior to final acceptance of the work.

1.34 SPECIALIST

A. The term "Specialist" as used in the specification shall mean an individual or firm of established reputation (or, if newly organized, whose personnel have previously established a reputation in the same field,) which is regularly engaged in, and which maintains a regular force of workers skilled in either (as applicable) manufacturing or fabricating items required by the contract, installing items required by the contract, or otherwise performing work required by the contract. Where the specification requires installation by a specialist, the term shall also be deemed to mean the manufacturer of the item, an individual or firm licensed by the manufacturer, or an individual or firm who will perform the work under the manufacturer's direct supervision.

1.35 CONTRACT CLOSEOUT SUBMITTALS

A. Project record documents:

1. Maintain on site one set of the following record documents; record actual revisions to the work of this division:

- a. Contract drawings.
- b. Specifications.
- c. Addenda.
- d. Change orders and other modifications to the Contract.
- e. Reviewed shop drawings, product data, and samples.

2. Maintain record documents separate from documents used for construction.

3. Record information concurrent with construction progress.

4. Specifications: Legibly mark and record in each section a description of actual products installed, including the following:

- a. Manufacturer's name and product model and number.
- b. Product options, substitutions, or alternates utilized.
- c. Changes made by addenda and modifications.

5. Record documents and shop drawings: Legibly mark each item to record actual construction, including:

- a. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
- b. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the work.
- c. Field changes of dimension and detail.
- d. Details not on original Contract Drawings.

6. Submit documents as specified in Division 01.

B. Operation and maintenance data:

1. Submit sets prior to final inspection as specified in Division 01. Unless otherwise specified in Division 01, submit no fewer than three sets. In addition to requirements specified in Division 01, submit operating and maintenance manuals for the work of this division as specified below.
2. Lubrication charts: Prepare lubrication charts for each piece of mechanical equipment that requires grease or oil.
 - a. Include the following:
 - (1) Types of lubricants required.
 - (2) Locations of lubrication points.
 - (3) Frequency of lubrication.
 - b. Provide one extra set of lubrication charts mounted in plastic covers, besides those required in Operating and Maintenance Manuals.
3. Binders: Provide large enough binders, and sufficient quantity, that the required contents can be easily turned, removed, and reinserted.
 - a. Self-expanding fast lock type.
 - b. Three telescoping metal posts.
 - c. Durable plastic covers.
 - d. Angle spline with guide flanges.
 - e. Text page size - 8.5 by 11 inches.
 - f. Boorum and Pease, Stock No. C-619-3 expansion 3 inch to 5 inch, or Stock No. C-1219 expansion 1.5 inch to 2.5 inch, or equal by National or Wilson Jones.
4. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS," and title of project. Print on spine of binder "O & M INSTRUCTIONS." If more than one binder is required, print covers and spines with volume numbers. Include in the front of every binder an index to all binders.
5. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.
6. Contents: Prepare a Table of Contents for each volume, with each product or system description identified, typed on white paper.
7. Part 1: Directory, listing names, addresses, and telephone numbers of mechanical engineers; Contractor; mechanical subcontractors; and major mechanical equipment suppliers.
8. Part 2: Operation and maintenance instructions, arranged by specification section. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers. Identify the following:
 - a. Significant design criteria, including pump curves and similar performance charts.
 - b. List of equipment, including operating weight of each piece.
 - c. Parts list for each component, including recommended spare parts list.
 - d. Operating instructions.
 - e. Maintenance instructions for equipment and systems.
 - f. Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.
 - g. Valve charts, including locations of flow fittings.
9. Part 3: Project documents and certificates, including the following:
 - a. Shop drawings and product data.
 - b. Photocopies of certificates.

- c. Photocopies of warranties and guarantees.
 - d. Test reports: Copies of the results of all tests required under all sections of specifications.
10. Submit one copy of completed volumes in final form 15 days prior to final inspection. This copy will be returned after final inspection, with Engineer comments. Revise content of documents as required prior to final submittal.
11. Submit final volumes revised, within ten days after final inspection.
12. Submit DVD optical disc storage media specified in Section 210500.

1.42 REGULATORY REQUIREMENTS

- A. When these specifications call for materials or construction of a better quality or larger sizes than required by the following codes and standards, the provisions of the specifications shall take precedence.
- B. Provide, without extra charge, any additional materials and labor that may be required for compliance with these codes and standards even though the work is not mentioned in these specifications or shown on the contract drawings.
- C. Perform the work of this division in strict accordance with the following authorities. The latest revision of these codes accepted by the authority having jurisdiction as of the date of the contract documents shall apply.
 - 1. The plumbing, mechanical, electrical, building, fire, and safety codes of the state and county or city in which the work is being performed.
 - 2. The National Electric Code, NFPA 70 (NEC).
 - 3. The National Fire Protection Association Code. (NFPA).
 - 4. International Energy Conservation, Fire, Fuel Gas, Mechanical, and Plumbing Codes (ICC).

1.43 REFERENCE STANDARDS

- A. Perform the work of this division using the standards of the following organizations, as referred to in technical sections, as a minimum requirement for construction and testing. Unless otherwise specified in Bidding and Contract Documents or Division 01, the latest revision current as of the date of the contract documents shall apply. Products shall be certified by manufacturers to meet the requirements of referenced standards.
 - 1. American National Standards Institute (ANSI)
 - 2. ASME International (ASME)
 - 3. American Society for Testing and Materials (ASTM)
 - 4. American Society of Sanitary Engineering (ASSE)
 - 5. American Water Works Association (AWWA)
 - 6. International Code Council (ICC)
 - 7. Manufacturer's Standardization Society of the Valve and Fittings Industry Inc. (MSS)
 - 8. National Electrical Code, NFPA 70 (NEC)
 - 9. National Electrical Manufacturer's Association (NEMA)
 - 10. National Fire Protection Association (NFPA)
 - 11. National Sanitary Foundation (NSF)
 - 12. The Occupational Safety and Health Act (OSHA)
 - 13. Piping and Drainage Institute (PDI)
 - 14. Underwriters Laboratory Inc. (UL)
 - 15. Maryland Occupational Safety and Health Act (MOSHA)

1.53 TEMPORARY STORAGE

- A. Maintain upon premises, where directed, a storage area, and be responsible for all contents within these areas. Provide all security measures necessary for this area.
- B. Area shall be maintained and shall be returned to original condition at the completion of the project.

1.54 PROTECTION

- A. Each trade and subcontractor is responsible for preventing damage and soiling of work performed by other trades or subcontractors. Each trade and subcontractor is responsible for providing temporary protection of its own work.
 - 1. Protect work from spills, splatters, drippings, adhesives, bitumens, mortars, paints, plasters, and damage from welding or burning.
 - 2. Protect finished work from damage, defacement, staining, or scratching.
 - 3. Protect finishes from cleaning agents, or grinding and finishing equipment.
 - 4. Protect adjacent and finished work from damage, using tape, masking, covers or coatings and protective enclosures.
 - 5. Coordinate installations and temporarily remove items to avoid damage from finishing work.
- B. Repair all damage or soiling to the complete satisfaction of the Architect; replace any materials or work damaged to such an extent that they cannot be restored to their original condition, all at no addition to the Contract Sum.
- C. Protect work stored in place and supplies stored in the building.
 - 1. Store materials and products, subject to damage from moisture, in dry locations. If necessary, provide in protective wraps or covers.
 - 2. Store plastics, other materials, and products subject to damage from heat or cool at manufacturer's recommended temperatures.
- D. Use of sidewalk or roadway areas outside of the property lines shall be with permission and approval of the local authorities having jurisdiction.

1.55 FIRE PROTECTION

- A. As a minimum, provide hand-carried, portable, UL-rated extinguishers with each work crew working inside the building.
- B. Select extinguishers in accordance with NFPA 10 and NFPA 241 for classification, extinguishing agent, and size required by location and class of fire exposure.

1.60 PROJECT CONDITIONS

- A. Drawings showing utilities in concealed locations are based on the best information available but are not represented as being precisely correct. Work of the contract includes digging, cutting, drilling, using nondestructive methods, and other methods of locating concealed utilities in the field, as well as patching and repairing as specified in "Cutting and Patching" below.
- B. If, in the course of the work, workers encounter a material they suspect to present some hazard:
 - 1. Promptly notify the Architect in writing.

2. Do not perform any work which would disturb the suspected material until written instructions have been received.

1.80 WARRANTY

- A. All work and equipment provided as work of this division shall be fully warranted under the general project warranty. In addition, provide added special warranties specified in individual sections.
- B. During the correction period, the Contractor shall promptly correct any work found to be not in accordance with the requirements of the Contract Documents, on receipt of written notice from the Owner. Except as otherwise required in General Conditions and Division 01, the correction period is two years after the date of substantial completion of the work. Work requiring correction shall promptly be repaired or completely replaced at no addition to the Contract Sum.
- C. When use of the permanent equipment has been permitted for temporary heating or ventilation of the building, the warranty and correction periods shall nevertheless begin at the time of substantial completion, unless another date of acceptance has been agreed to by the Owner.
- D. Special warranties are warranties required by individual specification sections, incidental product warranties, manufacturers' standard warranties, installer or subcontractor service agreements, and other individual warranties in addition to the general project warranty.
- E. Provide copies of warranties as required for Operation and Maintenance Manual specified above, and by Division 01.
- F. For items of work delayed beyond date of substantial completion, provide updated submittal within ten days after acceptance, listing date of acceptance as start of warranty period.

1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractors' and subcontractors' responsibilities are described in Division 01.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.11 CUTTING AND PATCHING

- A. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
- B. Cut walls, floors, partitions, roofs, and other appurtenances for the passage or accommodation of pipes, ducts and appurtenances. Close superfluous openings and remove all debris caused by work of this division.
- C. No cutting of any structure or finish shall be done until the condition requiring such cutting has been examined and approved by the Architect.

- D. New or existing surfaces disturbed as a result of such cutting or otherwise damaged shall be restored to match original work and all materials used for any patching or mending shall conform to the class of materials originally installed.
- E. Refinish surfaces to match adjacent finish. For continuous surfaces, refinish to nearest intersection or natural break. For an assembly, refinish entire unit.

3.14 TEMPORARY FACILITIES

- A. Temporary water facilities, electricity, telephone, toilet facilities, and temporary heat, shall be provided as specified in Division 01.

3.40 PROGRESS MEETINGS

- A. Progress meetings shall be held as specified in Division 01, and also when and if the Contractor or Architect finds them necessary or advantageous to progress of work.
- B. Contractor, those subcontractors and those material suppliers concerned with current progress or with the scheduling of future progress, Architect and Owner shall each be represented at these meetings by persons familiar with the details of work and authorized to conclude matters relating to work progress.

END OF SECTION 210101

SECTION 210500 - COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 - GENERAL

1.11 SUMMARY

Basic material and equipment required for the fire-suppression piping work as indicated on the drawings and specified in Division 21.

Other requirements applicable to more than one section of Division 21.

Identification of fire-suppression systems and equipment.

1.14 RELATED SECTIONS

- A. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.
- B. Project and special warranties: Division 01 and Section 210101.
- C. Operation and Maintenance Manuals: Division 01 and Section 210101.
- D. Painting: Division 09.

1.21 DEFINITIONS

Project correction period: A period after Substantial Completion of the work during which the Contractor shall correct every part of the work found to be not in accordance with the requirements of the contract documents, promptly after receipt of written notice.

Qualified testing agency: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ASTM E 548; and with additional qualifications specified in individual sections; and where required by authorities having jurisdiction, that is acceptable to authorities.

1. NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7.
2. NVLAP: A testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program.

DN: Dimension Nominale, nominal pipe size in millimeters, in accordance with the metric system for construction, Systeme Internationale (SI).

NPS: Nominal pipe size in inches, in accordance with standard U.S. designations for manufactured pipe. Pipe sizes do not change when projects are designed and built in metric units; each size has a consistent name (nominal dimension) in each system.

1.26 DESIGN REQUIREMENTS

The drawings and system performances have been designed based on using the particular manufacturer's products specified and scheduled on the drawings.

Products of other manufacturers that are listed under the article "Acceptable Manufacturers," or permitted as "equal," are permitted provided:

1. Product shall meet the specifications.
2. Contractor shall make, without addition to the contract sum, all adjustments for deviations so that the final installation is complete and functions as the design basis product is intended.

Do not propose products with dimensions or other characteristics different from the design basis product that render their use impractical, or cause functional fit, access, or connection problems.

The contract drawings are generally diagrammatic and do not indicate all fittings or offsets in pipe, all access panels, or other specialties required.

Install pipe exposed to view parallel with the lines of the building and as close to walls, columns, and ceilings as may be practical, maintaining proper clearances for access at all parts requiring servicing.

Install pipe a sufficient distance from other work to permit a clearance of not less than 0.5 inch (15 mm) between its finished covering and adjacent work.

No pipe shall be run below the head of a window or door.

Pull boxes and other appurtenances which require operation or maintenance shall be easily accessible. Do not cut or form handholes for operation or maintenance of appliances through walls or ceilings.

1.30 SUBMITTALS

Comply with Division 01 and Section 210101.

Shop drawings:

Schedule of welding and brazing procedures proposed for each piping system included in the project.

LEED submittal:

Product data for Indoor Environmental Quality (IEQ) Credit 4.4:

Certifications: Proof of operator and testing agency personnel qualifications as required for welding and brazing in the article "Quality Assurance" below.

Test reports: Field test results for each piping system as specified in Part 3 below.

1.40 QUALITY ASSURANCE

- A. Provide materials and perform work in accordance with the plumbing, mechanical, electrical, building, fire, health and safety, and other applicable codes and regulations of the state, county or city in which the work is performed.
- B. Welding procedures and operator qualifications for structural welding: AWS D1.1, Structural Welding Code Steel, electric arc process.
- C. Welding, brazing, and soldering procedures and operator qualifications for building systems piping:
 1. AWS D10.9, Qualification of Welding Procedures and Welders for Piping and Tubing.
 2. ASME B31.9, Building Services Piping.
- D. Qualifications of independent testing laboratory personnel:

1. Welding inspectors: AWS QC1, Certification of Welding Inspectors.
- E. Electrical control panels, equipment, materials and devices provided or installed as work of Division 21 shall bear UL label or, if UL label is not available, the item shall be tested and labeled by a qualified testing agency, acceptable to authorities having jurisdiction, and in accordance with NFPA 70 (NEC). Provide testing, if required, without addition to the contract sum.
- F. Qualifications of DVD documentation technician: For video documentation specified in "Operating Instructions (Demonstration)," employ persons knowledgeable in DVD optical storage media format for video and audio production and editing.
- G. The project shall be LEED certified. See requirements specified in Division 01 and individual sections for LEED requirements, waste and air quality control.

1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractors' and subcontractors' responsibilities are described in Division 01.

PART 2 - PRODUCTS

2.10 MATERIALS

- A. General piping techniques, testing, identification, painting, and operating instructions specified in this section apply to products specified in other sections of Division 21.
- B. Weldolets and thredolets: Fittings designed for installing branches on piping, with either welded or threaded connection to branch; conforming to ASTM A 234.
- C. Pipe jointing compound:
 1. Polytetrafluoroethylene (PTFE) pipe thread tape, "Teflon."
 2. Pipe cement and oil.

2.21 IDENTIFICATION DEVICES AND MATERIALS

- A. Stenciling materials:
 1. Stencils: Manufactured standard stencils prepared for required applications, conforming to ANSI A13.1 for color and size of legend letters, including arrows showing direction of flow.
 2. Paint: Exterior type enamel, colors conforming to ANSI A13.1, or black.
- B. Equipment identification tags:
 1. Laminated plastic with adhesive back, white core and black outer layers, which, when engraved, will produce white letters and numerals on a black background.
 2. Tags installed on curved surfaces shall be aluminum or brass.
- C. Valve tags: Brass, 1.5 inch (40 mm) in diameter with black-filled numbers not less than 0.25 inch (6 mm) high, complete with brass attachment chains.
- D. Ceiling identification tags: Laminated plastic with adhesive back, engraved black letters on white background, minimum 0.5 inch (15 mm) wide and length as required for 0.375 inch (10 mm) high letters for name of concealed device and number.

PART 3 - EXECUTION

3.03 INSTALLATION OF PRODUCTS AND EQUIPMENT

- A. Manufacturers' instructions: Except as modified by drawings or specifications, install products and equipment in accordance with manufacturers' instructions and recommendations applicable to the project conditions.
 - 1. Immediately notify Architect if a difference or discrepancy is found between manufacturers' instructions and the drawings or specifications.

3.22 PIPE INSTALLATION

- A. Remove burrs resulting from cutting pipe or from any other operation.
- B. Threaded connections:
 - 1. Cut threads full and clean.
 - 2. Apply specified pipe jointing compound or tape on male threads only.
- C. Thoroughly clean pipe and fittings before they are installed, and keep them clean until the acceptance of the completed work. Cap or plug the ends of the lines so as to prevent earth and other debris from entering during construction.
- D. Black steel piping NPS 2.5 (DN 65) and larger shall be welded; NPS 2 (DN 50) and smaller shall be threaded, except as required otherwise in a particular section.
- E. Do not weld galvanized piping.
- F. Use welding fittings, tees, wyes, reducers, eccentric reducers, and caps as required. Branches at least two nominal pipe sizes less than the main may be made with "Weldolets" or "Thredolets" installed with full size opening in larger pipe and in accordance with manufacturer's printed instructions. Flanges shall be welded neck or slip-on pattern of class to suit the valves or equipment connections. Flanges shall have machine bolts with hex nuts and washers.

3.25 INTERFACE WITH OTHER PRODUCTS

- A. Where it is necessary to run pipes through walls, provide finished, permanent, waterproof installation complete with inserts, sleeves, supports or hangers, seals, and other appurtenances as required. Do not pierce, cut, or notch any footing or other structural member.
- B. Waterproofing and dampproofing of the building shall be unharmed by the installation of the work. Where pipe has to pierce waterproofing or dampproofing, including outside walls, the penetration shall be made watertight. Waterproofing damaged or destroyed shall be repaired or replaced with new waterproofing.

3.59 IDENTIFICATION

- A. General: Do not apply identification until insulation and finish painting work is complete.
- B. Equipment:
 - 1. Stencil equipment with minimum two-inch (50-mm) -high letters or provide identification tags.

- Clearly identify function, equipment served, and area served.
2. Firmly fasten each identification tag to its appropriate piece of equipment with drive screws, sheet metal screws, or rivets. Do not interfere with operation of, or damage the item being marked.
- C. Piping:
1. Mark by stenciling.
 2. Mark to identify service with arrows showing direction of flow. Apply markings near building walls where pipes enter or leave an accessible space and in intermediate locations so that markings are no more than 30 feet (9 m) apart. They shall be readily visible to a person standing on the floor.
 3. Fully identify all piping installed as work of the project.
 4. Mark pipe with letters of height and with colors as required by OSHA and conforming to ANSI A13.1.
 5. Identify every gage, and control device.
 6. Provide valve tags for all valves. Numbers shall correspond to those shown on the Valve Chart. Attach tags to valve shaft.
- D. Ceiling identification tags: Provide on the access door or, in suspended ceilings, on the ceiling support adjacent to the device.
1. Valves: Identify with the same number shown on the valve tag.

3.61 PIPING TESTS

- A. Notify Owner at least one day prior to the actual test.
- B. Test before pipes are concealed or insulated. Test the piping in sections as the work progresses, so as not to delay progress of the building construction. Furnish pumps and gages required for testing.
- C. Conduct piping tests before connecting equipment that would be subject to damage from the test pressure. Replace piping or fittings found defective with new material.
- D. Bracing and supporting: Adequately brace and support piping during the test, so that no movement, displacement, or damage results from the application of the test pressure.
- E. Test the piping systems for not less than four hours to fulfill the conditions in the Piping Systems Test Schedule at the end of this section.
- F. Documentation of tests: Prepare a test report for each portion of piping tested, identified by service, material, location, and pipe size. Include these items:
 1. Date of test.
 2. Starting and completion times.
 3. Initial test pressure.
 4. Final test pressure.
 5. Problems or leaks detected.
 6. Corrective actions taken.
 7. Record of successful completion of testing.
 8. Name, title, and signature of person conducting test.

3.75 CLEANING AND PAINTING

- A. Cleaning: Clean piping and equipment. Where items are to be painted, clean and prepare surfaces for painting.
- B. Painting: Coordinate painting with requirements of Division 09. Paint the items identified below to be painted. Use paint materials and systems specified in Division 09.
- C. Items to be painted:
 - 1. Items identified below to have protective coating.
 - 2. Items furnished with manufacturer's prime coat.
 - 3. Mechanical rooms:
 - a. Piping.
 - b. Hangers and supports.
 - 4. Fire protection system piping throughout the building.
- D. Items not to be painted: Stainless steel and equipment furnished with manufacturer's finish.
- E. Paint piping in mechanical rooms: Paint piping using colors in accordance with ANSI A13.1 and as coordinated with the owner.
 - 1. Galvanized steel: One coat of primer recommended for galvanized surfaces and one coat of glossy alkyd enamel.
 - 2. Ferrous metal: One coat of primer recommended for ferrous metal and one coat of glossy alkyd enamel.
- F. Paint systems for exposed piping: Primer compatible with the substrate, whether steel, galvanized steel, insulation jacket, or other material; one coat or two, if required to cover, to match adjacent surfaces in color and texture.

3.81 OPERATING INSTRUCTIONS (DEMONSTRATION)

- A. Furnish the necessary technicians, skilled workers, and helpers to operate all the fire-suppression systems and equipment of the entire project for one 8-hour day.
- B. Where specified in technical sections, provide longer periods required for specialized equipment.
- C. Instruct the Owner or designated personnel in operation, maintenance, lubrication, and adjustment of all systems and equipment.
 - 1. Instructions by manufacturer's technical representative for each type of system shall include the performance of the recommended preventive maintenance procedures for that equipment.
- D. The Operating and Maintenance Manual shall be available at the time of the instructions, for use by instructors and Owner personnel.
- E. Record each instruction session only in DVD media format (video and audio format), including both the sessions specified above and added sessions required in technical sections for specialized equipment. Provide one complete set of DVDs with each Operating and Maintenance Manual.
- F. Schedule the general and specialized instruction periods for a time agreed upon by the Owner

and Architect.

3.90 SCHEDULES

A. Piping Systems Test Schedule:

SYSTEM	TEST PRESSURE PSIG (kPa)	ALLOWABLE DROP	MEDIUM
Sprinkler water and fire line	200 (1370)	None	Water

END OF SECTION 210500

SECTION 211000 - WATER-BASED FIRE-SUPPRESSION SYSTEM

PART 1 - GENERAL

1.10 SUMMARY

- A. This section includes the following fire suppression systems inside the building:
 - 1. Wet pipe sprinkler systems.
- B. Related sections include the following:
 - 1. Trenching Backfill and Compaction: Section 220501.
 - 2. Piping materials and joining requirements: Section 210500.
 - 3. Requirements for sleeves, supports, and other items related to piping systems: Division 22.
 - 4. Requirements for firestopping: Section 220507.

1.21 DEFINITIONS

- A. AHJ: Authority having jurisdiction, typically the fire marshal.
- B. Registered fire protection engineer:
 - 1. Registered professional engineer in Maryland.
 - 2. Bachelor's degree in fire protection engineering and no less than two years experience working in fire protection; or Bachelor's degree in engineering and no less than 4 years experience working in fire protection; or other combination of qualifications satisfactory to the AHJ.
- C. Underground service-entrance piping: Water service piping installed below grade in earth.

1.25 SYSTEM DESCRIPTIONS

- A. Wet pipe sprinkler system: Automatic sprinklers are attached to piping containing water and that is connected to water supply. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included if indicated.

1.26 DESIGN REQUIREMENTS

- A. Design the system by the hydraulic calculation method. Base data for calculations are shown on the drawings.
- B. Locations of service connection, mains and risers, zones, and Hazard Classifications are shown on drawings.
- C. Contractor's attention is called to Memorandum 01-88-206 from the Maryland State Fire Marshal which states; "elevator shafts and elevator mechanical rooms be equipped with an automatic fire suppression system ... within buildings which are Sprinklered ... with an automatic sprinkler system at the top and bottom of the elevator shaft and within the elevator machine room." Coordinate locations of sprinklers and piping with elevator equipment and requirements of local elevator inspection authority.

- D. Do not include area reductions for quick response sprinklers installed in light or ordinary hazard locations, allowed by NFPA, unless approved by both the insurance carrier and the Owner.

1.27 PERFORMANCE REQUIREMENTS

- A. Standard piping system component working pressure: Listed for at least 175 psig (1200 kPa).

1.30 SUBMITTALS

- A. Product data: Include copy of UL report verifying each product's UL listing for Fire Protection Service.
 - 1. Piping materials, including dielectric fittings, flexible connections, and sprinkler specialty fittings.
 - 2. Pipe hangers and supports.
 - 3. Valves, including listed fire protection valves, unlisted general duty valves, and specialty valves and trim.
 - 4. Each type of sprinkler, escutcheon, and guard. Include sprinkler flow characteristics, mounting, finish, and other pertinent data.
 - 5. Hose connections, including size, type, and finish.
 - 6. Fire department connections, including type; number, size, and arrangement of inlets; caps and chains; size and direction of outlet; escutcheon and marking; and finish.
 - 7. Alarm devices, including electrical data.
- B. Shop drawings: Diagram power, signal, and control wiring.
- C. Fire hydrant flow test report.
- D. Approved sprinkler piping drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations.
- E. 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" and "Contractor's Material and Test Certificate for Underground Piping".
- F. Welding certificates.
- G. Field quality control test reports.
- H. Operation and maintenance data: For sprinkler specialties to include in emergency, operation, and maintenance manuals.

1.40 QUALITY ASSURANCE

- A. Installer qualifications:
 - 1. Installer's responsibilities include designing, fabricating, and installing fire suppression 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.

- B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
- C. NFPA Standards: Fire-suppression-system equipment, specialties, accessories, installation, and testing shall comply with the following:
 - 1. NFPA 13, "Installation of Sprinkler Systems."
 - 2. NFPA 230, "Fire Protection of Storage."
- D. Pipe shall be certified by the manufacturer to meet referenced standards and shall bear a label directly on the pipe indicating compliance.

1.42 REGULATORY REQUIREMENTS

- A. Backflow preventers shall be installed by a licensed plumber. Coordinate fire suppression system piping installation with domestic water piping installation.

1.49 COORDINATION

- A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

1.91 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.
- B. Sprinkler cabinets, sprinklers, and wrench: Finished, wall-mounting, steel cabinet with hinged cover, with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler on project.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.11 BACKFLOW PREVENTERS

- A. Double-Check, Backflow-Prevention Assemblies:
 - 1. Standard: ASSE 1015
 - 2. Operation: Continuous-pressure applications unless otherwise indicated.
 - 3. Pressure Loss: 5 psig (35 kPa) maximum, through middle one-third of flow range.
 - 4. Body Material: Bronze for NPS 2 (DN 50) and smaller; stainless steel for NPS 2-1/2 (DN 65) and larger.
 - 5. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
 - 6. Configuration: Designed for horizontal, straight through flow.

7. Accessories: Ball valves with threaded ends on inlet and outlet of NPS 2 (DN 50) and smaller; OS&Y gate valves with flanged ends on inlet and outlet of NPS 2-1/2 (DN 65) and larger.

2.20 ABOVEGROUND PIPE AND FITTINGS

- A. Pipe: Metal, rigid types permitted by NFPA 13, UL listed and FM approved, suitable for specified fittings.
- B. Fittings: Compatible with pipe, types permitted by NFPA 13, UL listed and FM approved.
 1. Exceptions: Compression fitting shall be mechanical coupling for grooved pipe only; other compression types are not permitted.
- C. Hangers and supports: UL approved, supporting piping from above, black steel conforming to NFPA 13.

2.21 UNDERGROUND PIPE AND FITTINGS

- A. Pipe: Class 54, cement-mortar-lined ductile iron AWWA C-151.
- B. Mechanical or push-on joints: AWWA C-111.
- C. Fittings: AWWA C-110 ductile iron, Class 350.

2.22 SPRINKLER SPECIALTY FITTINGS

- A. Sprinkler specialty fittings shall be UL listed or FMG approved, with 175-psig (1200-kPa) minimum working-pressure rating, and made of materials compatible with piping. Sprinkler specialty fittings shall have 250-psig (1725-kPa) minimum working-pressure rating if fittings are components of high-pressure piping system.
- B. Sprinkler drain and alarm test fittings: Cast or ductile iron body; with threaded or locking lug inlet and outlet, test valve, and orifice and sight glass.
- C. Sprinkler inspector's test fitting: Cast or ductile iron housing with threaded inlet and drain outlet and sight glass.
- D. Drop-nipple fittings: UL 1474, adjustable with threaded inlet and outlet, and seals.

2.23 LISTED FIRE-PROTECTION VALVES

- A. Manufacturers:
 1. Crane Co.; Crane Valve Group; Crane Valves
 2. Crane Co.; Crane Valve Group; Jenkins Valves
 3. Hammond Valve
 4. McWane Inc.; Kennedy Valve Div.
 5. Milwaukee Valve Co.
 6. Mueller Company
 7. NIBCO
 8. Potter-Roemer; Fire Protection Div.
 9. Reliable Automatic Sprinkler Co., Inc.
 10. Stockham
 11. Tyco Fire Protection

12. Victaulic Co. of America

- B. Valves shall be UL listed or FM approved, with 175-psig (1200 kPa) minimum pressure rating. Valves shall have 250-psig (1725-kPa) minimum.
 - 1. Valves where required by NFPA 13 to be supervised shall be capable of being locked open with a guarded-shackle padlock equal to Master Lock No. 37.
- C. Gate valves: Equal to NIBCO F-607-0, NPS 2.5 through 12 (DN 65 through 300), iron body, OS&Y bolted bonnet, solid wedge, 175 pounds WWP.
- D. Butterfly valve: Lug type, equal to NIBCO LD3510-2, NPS 2 through 12 (DN 65 through 300), with gear operator, wheel, and flag, 175 pounds WWP.

2.24 SPECIALTY VALVES

- A. Sprinkler system control valves: UL listed or FM approved, cast- or ductile-iron body with flanged or grooved ends, and 175-psig (1200-kPa) minimum pressure rating. Control valves shall have 250-psig (1725-kPa) minimum.
- B. Alarm check valves: Equal to Tyco Model AV-1-300 in combination with Model RC-1 retarding chamber, bronze grooved seat with O-ring seals, and trim set for external bypass; clapper assembly mounted in valve body with a hinge pin plug and dual springs.
- C. Automatic ball drip valves: Equal to Elkhart No. 701, NPS 0.75 (DN 20), cast brass, ball check device with threaded ends.
 - 1. Finish: Rough brass.
- D. Water solenoid valve: Normally closed type, one NPT, one inch orifice, PTFE seal, 120 volt coil, equal to Automatic Switch Co., ASCO 8210D4.

2.28 SPRINKLERS

- A. Sprinklers shall be UL listed or FMG approved, with 175-psig (1200-kPa) minimum pressure rating.
- B. Sprinkler types and categories:
 - 1. Provide quick-response type.
 - 2. Provide high-temperature heat-responsive elements where required.
 - 3. Open sprinklers: UL 199, without heat-responsive element.
 - a. Orifice: 0.5 inch (12.7 mm), with discharge coefficient K between 5.3 and 5.8.
 - b. Orifice: 0.53125 inch (13.5 mm), with discharge coefficient K between 7.4 and 8.2.
 - 4. Extended coverage sprinklers are not acceptable.
- C. Sprinkler types, features, and options as indicated in Part 3.
- D. Sprinkler finishes: White in areas with ceilings, and plain brass in other areas.
- E. Special coatings: Lead and corrosion-resistant paint.

- F. Sprinkler escutcheons: White for sidewall and ceiling mounting.
- G. Sprinkler guards: Wire cage type, including fastening device for attaching to sprinkler. Provide guards on sprinklers mounted in gymnasium, cafeteria, mechanical rooms and where mounted 7.5 feet above floor and lower.
- H. Where required by the authority having jurisdiction, provide heat deflectors of proper size, painted to match surrounding area.
- I. Flexible sprinkler hose fitting assemblies are not acceptable.

2.32 FIRE DEPARTMENT CONNECTIONS

- A. Wall-type, fire department connection: UL listed, 175-psig (1200-kPa) minimum pressure rating; with corrosion resistant metal body with brass inlets, brass wall escutcheon plate, brass lugged caps with gaskets and brass chains, and brass lugged swivel connections. Include 2.5 inch inlets with threads according to NFPA 1963 and matching local fire department sizes and threads, outlet with pipe threads, extension pipe nipples, check devices or clappers for inlets, and escutcheon plate with marking similar to "AUTO SPKR & STANDPIPE," or "AUTO-SPKR."
 - 1. Type: Flush, with two inlets and square or rectangular escutcheon plate.
 - 2. Type: Exposed, projecting, with two inlets and round escutcheon plate.
 - 3. Finish: Polished brass.

2.33 ALARM DEVICES

- A. Alarm device types shall match piping and equipment connections.
- B. Water motor operated alarm: UL 753, mechanical-operation type with pelton-wheel operator with shaft length, strainer, bearings, and sleeve to suit wall construction and 10-inch- (250-mm-) diameter, cast-aluminum alarm gong with red-enamel factory finish. Include NPS 3/4 (DN 20) inlet and NPS 1 (DN 25) drain connections.
- C. Electrically operated alarm: UL 464, with 10-inch- (250-mm-) diameter, vibrating-type, metal alarm bell with red-enamel factory finish and suitable for outdoor use.
- D. Water flow indicator: UL listed, equal to Notifier Corporation Model WFD, electrical-supervision, paddle-operated-type, water-flow detector with 250-psig (1725-kPa) pressure rating and designed for horizontal or vertical installation. Include 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.
- E. Valve supervisory switch: UL listed, equal to Notifier Model OSY2, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled valve is in other than fully open position with tamperproof cover that sends signal when removed.
- F. Indicator-post supervisory switch: UL listed, equal to Notifier Model PIBV2, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled indicator-post valve is in other than fully open position.

2.34 PRESSURE GAGES

- A. Description: 4.5-inch- (115-mm-) diameter, dial pressure gage with range of 0 to 250 psig (0 to 1725 kPa) minimum.
 - 1. Water system piping: Include caption "WATER" on dial face.

2.35 SIGNAGE

- A. Metal signs: Comply with NFPA 13 requirements.

PART 3 - EXECUTION

3.07 EARTHWORK

- A. Refer to Section 220501 for excavating, trenching, and backfilling.

3.20 PIPING APPLICATIONS, GENERAL

- A. Shop weld pipe joints where welded piping is indicated.
- B. Do not use welded joints for galvanized-steel pipe.
- C. Flanges, flanged fittings, unions, nipples, and transition and special fittings with finish and pressure ratings same as or higher than system's pressure rating may be used in aboveground applications, unless otherwise indicated.

3.21 JOINT CONSTRUCTION

- A. Refer to Section 21 0500, Common Work Results for Fire Suppression, for basic piping joint construction.
- B. Threaded joints: Comply with NFPA 13 for pipe thickness and threads. Do not thread pipe with wall thickness less than Schedule 40.
- C. Twist locked joints: Insert plain end piping into locking lug fitting and rotate retainer lug one quarter turn.
- D. Grooved joints: Assemble joints with listed coupling and gasket, lubricant, and bolts.
 - 1. Ductile iron pipe: Radius cut groove ends of piping. Use grooved end fittings and grooved end pipe couplings.
 - 2. Steel pipe: Square cut or roll groove piping as indicated. Use grooved end fittings and rigid, grooved end pipe couplings, unless otherwise indicated.
 - 3. Copper tube: Roll groove tubing. Use grooved end fittings and grooved end tube couplings.
 - 4. Dry pipe systems: Use fittings and gaskets listed for dry-pipe service.
- E. Dissimilar-metal piping joints: Construct joints using dielectric fittings compatible with both piping materials.
 - 1. NPS 2 (DN 50) and smaller: Use dielectric unions, couplings, or nipples.
 - 2. NPS 2.5 to NPS 4 (DN 65 to DN 100): Use dielectric flanges.
 - 3. NPS 5 (DN 125) and larger: Use dielectric flange insulation kits.

3.22 SERVICE ENTRANCE PIPING

- A. Connect fire suppression piping to water service piping of size and in location indicated for service entrance to building.
- B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water service piping.

3.23 ABOVEGROUND PIPING INSTALLATION

- A. Install piping above the finished ceiling wherever ceilings occur. For bar joist construction, run the pipes between or threaded through bar joists, arranged so as to give clear path for ductwork, lighting fixtures, and appurtenances below joists and to permit possible clearance for future relocation of light fixtures and ductwork. Consult Finish Schedules on Architectural drawings. Do not install piping so that it blocks access doors or panels of ductwork, air handling equipment, or the space required for filter removal. Provide padlocks for valves.
 - 1. The finished ceilings shall not be erected until all fire protection piping has been installed, tested, and inspected.
 - 2. Hanger spacing shall conform to NFPA 13.
- B. System drains shall be piped to drain into service sinks, drains, or through wall to grade with all exterior fittings of brass. At low points in piping provide ball valves with hose nipples with vacuum breakers.
 - 1. Except as shown otherwise on drawings, drains 1.5 inches and larger shall be piped through wall to grade.
- C. Obtain written approval from Architect for necessary openings through steel beams for passage of sprinkler pipes. Make openings as small as possible. Where necessary, reinforce the beams around openings with welded steel plates or angle irons in accordance with Architect's details or instructions. Perform cutting, welding, and reinforcing as specified in Structural Steel Section of Specifications, including requirements for welders' certification and for inspection and testing. Costs for this inspection shall be paid by the Contractor. Provide certification of each inspection as required in "Submittals" in Part 1 above.
- D. Provide backflow preventers where required by authority having jurisdiction.

3.24 UNDERGROUND PIPING INSTALLATION

- A. Pipe: Install as indicated on the drawings including underground pipe serving remote freestanding fire department connections.
- B. Joints: Mechanical or push-on.
- C. Provide electrical continuity at pipe joints or fireline service with conductivity strips, wedges or other methods approved by the Architect.
- D. Use proper and suitable tools and appliances for the safe and convenient handling and laying of the pipe. Do not damage the pipe coating. Examine all sections of pipe for defects and do not use any defective piece. If any defective piece should be discovered after having been laid, remove it and replace it with a sound one at no change to the contract price.

- E. Install concrete abutments at changes in direction. The abutments shall be not less than three pipe diameters in width and two pipe diameters in height and shall rest on and transmit all thrust to undisturbed earth.
- F. Anchor fireline service pipes at point of entrance into building by means of clamps or special fittings. Method shall be approved by the Architect.
- G. At the point of water service entrance, provide a shutoff valve as indicated.

3.25 VALVE INSTALLATION

- A. Install listed fire-protection 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. Alarm check valves: Install in vertical position for proper direction of flow, including bypass check valve and retarding chamber drain line connection.

3.26 SPRINKLER APPLICATIONS

- A. Installation in suspended ceilings:
 - 1. Locate sprinklers in the geometrical centers of acoustical panels or in the geometrical centers of either half of rectangular acoustical panels. Provide pipe, fittings, and number of sprinklers to accomplish this, with no addition to the contract sum.
- B. Adjustable recessed pendent: Areas with ceilings.
- C. Adjustable pendent: Areas with obstructions such as surface-mounted light fixtures.
- D. Upright: Areas without ceilings.
- E. Concealed, including cover plate: Where noted.
- F. Dry: Refrigerator.
- G. Sidewall, dry: Where noted.
- H. Sidewall: Kitchen hood ducts and plenums.
- I. Institutional pendent and horizontal sidewall sprinklers: Where noted.

3.28 SPRINKLER CABINET

- A. Securely mount spare sprinkler cabinet to wall at location shown on the drawings.

3.31 FIRE DEPARTMENT CONNECTION INSTALLATION

- A. Install wall type, fire department connections in vertical wall.
- B. Install ball drip valve at each check valve for fire department connection.

3.32 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Connect water-supply piping to fire suppression piping. Include backflow preventer between potable water piping and fire suppression piping.
- D. Install ball drip valves at each check valve for fire department connection. Drain to floor drain or outside building.
- E. Connect piping to specialty valves, hose valves, specialties, fire department connections, and accessories.
- F. Electrical connections: Power wiring is specified in Division 26.
- G. Connect alarm devices to fire alarm.
- H. Ground equipment according to Section 260526.
- I. Connect wiring according to Section 260519.
- J. 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.

3.59 LABELING AND IDENTIFICATION

- A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13 and in Section 210500.

3.60 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. Leak test after installation:
 - a. Charging medium: water.
 - b. Test pressure and duration of test as required by NFPA 13.
 - c. Repair leaks and retest until no leaks exist.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Energize circuits to electrical equipment and devices.
 - 4. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" chapter.
 - 5. Coordinate with fire alarm tests. Operate as required.

- B. Report test results promptly and in writing to Architect and authorities having jurisdiction.
- C. Grooved pipe installation:
 - 1. Install grooved joints in accordance with the manufacturer's latest published installation instructions. Grooved ends shall be clean and free from indentations, projections, and roll marks. Gaskets shall be molded and produced by the coupling manufacturer, and shall be verified as suitable for the intended service.
 - 2. A factory-trained field representative (direct employee) of the mechanical joint manufacture shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. The factory-trained representative shall periodically review the product installation and ensure best practices are being followed. Contractor shall remove and replace any improperly installed products. A distributor's representative is not considered qualified to conduct the training.

3.75 CLEANING AND PROTECTION

- A. Clean dirt and debris from sprinklers.
- B. Remove and replace sprinklers with paint other than factory finish.
- C. Protect sprinklers from damage until Substantial Completion.

3.81 DEMONSTRATION

- A. Engage a factory authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves. Refer to Division 01 and Section 210101.

END OF SECTION 211000

SECTION 220101 - PLUMBING GENERAL PROVISIONS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. General provisions and requirements for all plumbing work.

1.14 RELATED SECTIONS

- A. Requirements of this section generally supplement requirements of Division 01.
- B. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.

1.20 REFERENCES

- A. NFPA 10: Portable Fire Extinguishers.
- B. NFPA 241: Safeguarding Construction, Alteration, and Demolition Operations.

1.25 SYSTEM DESCRIPTION

- A. The full set of Contract Documents applies to work of Division 22.
- B. Visit the site and study all aspects of the project and working conditions, as required by General and Supplementary Conditions, Bidding and Contracting Requirements, Drawings, and Specifications. Verify field dimensions.
- C. The work covered in technical sections includes the furnishing of all labor, equipment and materials, and the performance of all operations pertinent to the work described.
- D. Except as required otherwise in Division 01, promptly obtain and pay for, including all necessary signatures and paperwork, all permits, fees and inspections required for work of this division by authorities having jurisdiction, including any utility connection or extension charge. No payment will be made until a copy of the permit is forwarded to the Owner.
- E. Plumbing work of this project includes, as a brief general description, the following:
 - 1. Provide new domestic cold, hot, and recirculating hot water, sanitary vent and storm water systems to serve the new building.
 - 2. Provide natural gas-fired domestic water heater equipment and mixing valves.
 - 3. Provide new plumbing fixtures and all appurtenances.
 - 4. The project includes commissioning under the direction of a Commissioning Agent (CxA).
 - 5. The project will be LEED certified.
- F. See Division 01 for requirements related to LEED certification, commissioning, Owner's occupancy of the premises, limits on use of site, time restrictions on work, limits on utility outages or shutdowns, and phasing (sequencing) and scheduling.

1.26 PRODUCT OPTIONS

- A. Except as modified by provisions of Bidding and Contracting Requirements and Division 01, these options apply to Division 22 specifications.

- B. General: Where Contractor is permitted to use a product other than the specified item and model named as the basis of design, Contractor is responsible for all coordination and additional costs as specified in the article "Substitutions," below for substitutions.
- C. Products specified by reference standards or by description only: Any product meeting those standards or description.
- D. Products specified by naming one or more manufacturers, or model name or catalog reference number: Products specified establish a standard of quality, options to be included, and performance.
 - 1. Where other acceptable manufacturers are named, Contractor may provide products of those named manufacturers only, which meet the specifications.
 - 2. Where specification permits "equal" products, without naming other acceptable manufacturers, Contractor may use products of any manufacturer, which meet the specifications.
- E. Products specified by naming one manufacturer and particular product, with no provision for other options: No options or substitutions allowed.

1.27 SUBSTITUTIONS

- A. Substitutions will be considered only as permitted or required by the Bidding and Contracting Requirements and Division 01. Except as modified by those requirements, the requirements below apply to Division 22 specifications.
- B. Substitutions may be considered when a product becomes unavailable through no fault of the Contractor.
- C. Document each request with complete data substantiating compliance of proposed substitution with contract documents.
- D. A request constitutes a representation that the Bidder or Contractor:
 - 1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product.
 - 2. Will provide the same warranty for the substitution as for the specified product.
 - 3. Will coordinate installation and make changes to other work which may be required for the work to be complete with no additional cost to Owner.
 - 4. Waives claims for additional costs or time extension which may subsequently become apparent.
 - 5. Will reimburse Owner for review or redesign services associated with re-approval by authorities.
- E. Substitutions will not be considered when they are indicated or implied on shop drawing or product data submittals, without separate written request, or when acceptance will require revision to the Contract Documents.
- F. Substitution submittal procedure is specified in Bidding and Contracting Requirements and Division 01.

1.28 MATERIALS AND EQUIPMENT

- A. All materials and equipment shall be new and the best of their respective kinds, suitable for the conditions and duties imposed on them by the project, and of representative manufacturer. The description, characteristics and requirements of the materials to be used shall be in accordance with the specifications.
- B. All equipment, construction and installation must meet requirements of local, state and federal governing codes.
- C. Singular number: In cases where material, a device, or part of the equipment is referred to in the singular number in the specifications, it is intended that such reference shall apply to as many items of material, devices, or parts of the equipment as are required to complete the installation as shown on the drawings or required for proper operation of the system.
- D. Terms have the following meanings:
 - 1. Furnish: Supply item
 - 2. Install: Mount and connect item
 - 3. Provide: Furnish and install.
- E. All materials and equipment shall be installed and completed in a first class and workmanlike manner and in accordance with the best modern methods, practice and manufacturers' instructions. Any work which shall not present an orderly and neat or workmanlike appearance shall be removed and replaced with satisfactory work when so directed in writing by the Architect.
- F. The specifications and drawings are intended to define the minimum requirements, as to quality of materials, construction, finish and overall workmanship.
- G. General Conditions describe the correlation and intent of the Contract Documents. In case of discrepancies between the specifications and drawings, the specifications should be followed as to the general methods and principles and the drawings followed as to sizes, capacities and specifics for corresponding parts. If sizes are omitted, the Architect will determine sizes to be utilized.
- H. In all cases of doubt, uncertainty, or conflict as to the true meaning of the specifications or drawings, it is the responsibility of the Contractor to notify the Architect of said uncertainty, doubt, or conflict and obtain a decision as to the intent before starting any work which may be affected by this decision.

1.29 COORDINATION

- A. Should a situation develop during construction to prevent the proper installation of any equipment or item where shown on the drawings, call the situation to the attention of the Architect and await a written decision.
- B. Plan and coordinate all work to proceed in an orderly and continuous manner without undue delay, and in conformance with project schedule. Submit samples, shop drawings, schedules, insurance policies and certificates, and the like in time to avoid delays in actual construction. Coordinate plumbing work so that work of each trade is completed before other construction begins which would obstruct it.
- C. Coordinate trades to ensure that proper clearances between work of the various trades allow access to items which require operation and maintenance.

- D. Coordinate location and elevation of all piping, ductwork, light fixtures, equipment, and appurtenances in such a manner that the finished installation is as indicated on drawings. In the event difficulties are encountered which prevent this, it is the Contractor's responsibility to bring this to the attention of the Architect prior to initiation of work. Correct improperly coordinated installation at no additional cost.
- E. The Contractors' assistants shall include a competent foreman, who shall be on the premises at all times to check, layout, coordinate and superintend the installation of work. The foreman shall establish all grades and lines relative to the work before starting, and be responsible for the accuracy thereof.

1.30 SUBMITTALS

A. Manufacturers' and subcontractors' lists:

- 1. As specified in Division 01, submit a complete list of proposed manufacturers for all equipment, materials and subcontractors used for the work of this division. Lists shall follow the sequence of the specifications. No considerations will be given for partial or incomplete lists. After review of lists, submit shop drawings and product data.

B. Shop drawings and product data:

- 1. Submit in accordance with the requirements of Division 01 or as established at the preconstruction conference, the required number of copies of shop drawings and product data for every item of equipment. Shop drawings or product data will not be considered until manufacturers' lists have been approved. Shop drawings and product data shall be submitted, as required by the General Conditions, with sufficient time for checking, return to Contractor, and resubmission as required before Contractor shall install any item.
- 2. Each item submitted shall be properly labeled, indicating the specific service for which the equipment or material is to be used, section and paragraph number of specification or drawing number to which it applies, Contractor's name and project name and number. Data submitted shall be specific and shall include product data and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents. Clearly identify each item within the data. Data of a general nature will not be accepted. Each sheet must clearly show the project name and number.
- 3. The review of a shop drawing or product data shall not be considered as a guarantee of the measurements or building conditions or that the shop drawings or product data have been checked to see that item submitted properly fits the building conditions. This review shall not relieve the Contractor of the responsibility for furnishing material or performing work as required by the contract documents, for correctness of dimensions and quantities, or for proper coordination of details and interfaces among trades.
- 4. All exclusively electrical items furnished as items associated with plumbing items but not specifically described in the plumbing item submission, shall be submitted as a separate submittal but shall be clearly marked as associated with the plumbing item by identification specification paragraph.
- 5. Product data sheets shall be 8.5-inch by 11-inch cut sheets for operating and maintenance manual.

C. Submit at least three copies of the results of every test required under any section in this division.

- D. Specialist shall submit a list of at least three projects similar to this project in type, size, and quality, which have been in place and operating satisfactorily for at least five years.

1. Include project name, address, name and phone number of owner's representative, and project type and size.

E. After the work is completed, submit all required certificates of approval from approved inspection agencies and authorities having jurisdiction over work of this division. Certificates of approval must be received by the Architect prior to final acceptance of the work.

1.34 SPECIALIST

A. The term "Specialist" as used in the specification shall mean an individual or firm of established reputation (or, if newly organized, whose personnel have previously established a reputation in the same field,) which is regularly engaged in, and which maintains a regular force of workers skilled in either (as applicable) manufacturing or fabricating items required by the contract, installing items required by the contract, or otherwise performing work required by the contract. Where the specification requires installation by a specialist, the term shall also be deemed to mean the manufacturer of the item, an individual or firm licensed by the manufacturer, or an individual or firm who will perform the work under the manufacturer's direct supervision.

1.35 CONTRACT CLOSEOUT SUBMITTALS

A. Project record documents:

1. Maintain on site one set of the following record documents; record actual revisions to the work of this division:

- a. Contract drawings.
- b. Specifications
- c. Addenda
- d. Change orders and other modifications to the Contract
- e. Reviewed shop drawings, product data, and samples

2. Maintain record documents separate from documents used for construction.

3. Record information concurrent with construction progress.

4. Specifications: Legibly mark and record in each section a description of actual products installed, including the following:

- a. Manufacturer's name and product model and number
- b. Product options, substitutions, or alternates utilized
- c. Changes made by addenda and modifications

5. Record documents and shop drawings: Legibly mark each item to record actual construction, including:

- a. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
- b. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the work.
- c. Field changes of dimension and detail.
- d. Details not on original Contract Drawings.

6. Submit documents as specified in Division 01.

B. Operation and maintenance data:

1. Submit sets prior to final inspection as specified in Division 01. Unless otherwise specified in Division 01, submit no fewer than three sets. In addition to requirements specified in Division 01, submit operating and maintenance manuals for the work of this division as specified below.
2. Lubrication charts: Prepare lubrication charts for each piece of mechanical equipment that requires grease or oil.
 - a. Include the following:
 - (1) Types of lubricants required
 - (2) Locations of lubrication points
 - (3) Frequency of lubrication.
 - b. Provide one extra set of lubrication charts mounted in plastic covers, besides those required in Operating and Maintenance Manuals.
3. Binders: Provide large enough binders, and sufficient quantity, that the required contents can be easily turned, removed, and reinserted.
 - a. Self-expanding fast lock type.
 - b. Three telescoping metal posts.
 - c. Durable plastic covers.
 - d. Angle spline with guide flanges.
 - e. Text page size - 8.5 by 11 inches.
 - f. Boorum and Pease, Stock No. C-619-3 expansion 3 inch to 5 inch, or Stock No. C-1219 expansion 1.5 inch to 2.5 inch, or equal by National or Wilson Jones.
4. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS," and title of project. Print on spine of binder "O & M INSTRUCTIONS." If more than one binder is required, print covers and spines with volume numbers. Include in the front of every binder an index to all binders.
5. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.
6. Contents: Prepare a Table of Contents for each volume, with each product or system description identified, typed on white paper.
7. Part 1: Directory, listing names, addresses, and telephone numbers of mechanical engineers; Contractor; mechanical subcontractors; and major mechanical equipment suppliers.
8. Part 2: Operation and maintenance instructions, arranged by specification section. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers. Identify the following:
 - a. Significant design criteria, including pump curves and similar performance charts.
 - b. List of plumbing equipment, including operating weight of each.
 - c. Parts list for each plumbing fixture, faucet, and pump, including recommended spare parts list.
 - d. Operating instructions.
 - e. Maintenance instructions for plumbing equipment and systems.
 - f. Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.
 - g. Valve charts, including locations of flow fittings.
 - h. New burner installations: Include firing rate, nozzle size, and fuel pressure.

9. Part 3: Project documents and certificates, including the following:
 - a. Shop drawings and product data for plumbing systems.
 - b. Water balance reports.
 - c. Photocopies of certificates.
 - d. Photocopies of warranties and guarantees.
 - e. Test reports: Copies of the results of all tests required under all sections of specifications.
10. Submit one copy of completed volumes in final form 15 days prior to final inspection. This copy will be returned after final inspection, with Engineer comments. Revise content of documents as required prior to final submittal.
11. Submit final volumes revised, within ten days after final inspection.
12. Submit DVD optical disc storage media specified in Section 220500.

1.42 REGULATORY REQUIREMENTS

- A. When these specifications call for materials or construction of a better quality or larger sizes than required by the following codes and standards, the provisions of the specifications shall take precedence.
- B. Provide, without extra charge, any additional materials and labor which may be required for compliance with these codes and standards even though the work is not mentioned in these specifications or shown on the contract drawings.
- C. Perform the work of this division in strict accordance with the following authorities. The latest revision of these codes accepted by the authority having jurisdiction as of the date of the contract documents shall apply.
 1. The plumbing, mechanical, electrical, building, fire, and safety codes of the state and county or city in which the work is being performed.
 2. The National Electric Code, NFPA 70 (NEC).
 3. The National Fire Protection Association Code. (NFPA).
 4. International Energy Conservation, Fire, Fuel Gas, Mechanical, and Plumbing Codes (ICC).

1.43 REFERENCE STANDARDS

- A. Perform the work of this division using the standards of the following organizations, as referred to in technical sections, as a minimum requirement for construction and testing. Unless specified otherwise in Bidding and Contract Documents or Division 01, the latest revision current as of the date of the contract documents shall apply. Products shall be certified by manufacturers to meet the requirements of referenced standards.
 1. Federal Specifications (FS)
 2. ASME International (ASME)
 3. American Society for Testing and Materials (ASTM)
 4. American Society of Sanitary Engineering (ASSE)
 5. American Water Works Association (AWWA)
 6. International Code Council (ICC)
 7. Manufacturer's Standardization Society of the Valve and Fittings Industry Inc. (MSS)
 8. National Electrical Code, NFPA 70 (NEC)
 9. National Electrical Manufacturer's Association (NEMA)
 10. National Fire Protection Association (NFPA)
 11. National Fuel Gas Code, NFPA 54
 12. The Occupational Safety and Health Act (OSHA)

13. Piping and Drainage Institute (PDI)
14. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA)
15. Underwriters Laboratory Inc. (UL)
16. Maryland Occupational Safety and Health Act (MOSHA)

1.53 TEMPORARY STORAGE

- A. Maintain upon premises, where directed, a storage area, and be responsible for all contents within these areas. Provide all security measures necessary for this area.
- B. Area shall be maintained and shall be returned to original condition at the completion of the project.

1.54 PROTECTION

- A. Each trade and subcontractor is responsible for preventing damage and soiling of work performed by other trades or subcontractors. Each trade and subcontractor is responsible for providing temporary protection of its own work.
 1. Protect work from spills, splatters, drippings, adhesives, bitumens, mortars, paints, plasters, and damage from welding or burning.
 2. Protect finished work from damage, defacement, staining, or scratching.
 3. Protect finishes from cleaning agents, or grinding and finishing equipment.
 4. Protect adjacent and finished work from damage, using tape, masking, covers or coatings and protective enclosures.
 5. Coordinate installations and temporarily remove items to avoid damage from finishing work.
- B. Repair all damage or soiling to the complete satisfaction of the Architect; replace any materials or work damaged to such an extent that they cannot be restored to their original condition, all at no addition to the Contract Sum.
- C. Protect work stored in place and supplies stored in the building.
 1. Store materials and products, subject to damage from moisture, in dry locations. If necessary, protect in wraps or covers.
 2. Store plastics, other materials, and products subject to damage from heat or cold at manufacturer's recommended temperatures.
- D. Use of sidewalk or roadway areas outside of the property lines shall be with permission and approval of the local authorities having jurisdiction.

1.55 FIRE PROTECTION

- A. As a minimum, provide hand-carried, portable, UL-rated extinguishers with each work crew working inside the building.
- B. Select extinguishers in accordance with NFPA 10 and NFPA 241 for classification, extinguishing agent, and size required by location and class of fire exposure.

1.60 PROJECT CONDITIONS

- A. Drawings showing utilities in concealed locations are based on the best information available but are not represented as being precisely correct. Work of the contract includes digging, cutting, drilling, using nondestructive methods, and other methods of locating concealed utilities in the field, as well as patching and repairing as specified in "Cutting and Patching" below.
- B. If, in the course of the work, workers encounter a material they suspect to present some hazard:
 - 1. Promptly notify the Architect in writing.
 - 2. Do not perform any work which would disturb the suspected material until written instructions have been received.

1.80 WARRANTY

- A. All work and equipment provided as work of this division shall be fully warranted under the general project warranty. In addition, provide added special warranties specified in individual sections.
- B. During the correction period, the Contractor shall promptly correct any work found to be not in accordance with the requirements of the Contract Documents, on receipt of written notice from the Owner. Except as otherwise required in General Conditions and Division 01, the correction period is two years after the date of substantial completion of the work. Work requiring correction shall promptly be repaired or completely replaced at no addition to the Contract Sum.
- C. When use of the permanent equipment has been permitted for temporary heating or ventilation of the building, the warranty and correction periods shall nevertheless begin at the time of substantial completion, unless another date of acceptance has been agreed to by the Owner.
- D. Special warranties are warranties required by individual specification sections, incidental product warranties, manufacturers' standard warranties, installer or subcontractor service agreements, and other individual warranties in addition to the general project warranty.
- E. Provide copies of warranties as required for Operation and Maintenance Manual specified above, and by Division 01.
- F. For items of work delayed beyond date of substantial completion, provide updated submittal within ten days after acceptance, listing date of acceptance as start of warranty period.

1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.11 CUTTING AND PATCHING

- A. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
- B. Cut walls, floors, partitions, roofs, and other appurtenances for the passage or accommodation of pipes, ducts and appurtenances. Close superfluous openings and remove all debris caused by work of this division.
- C. No cutting of any structure or finish shall be done until the condition requiring such cutting has been examined and approved by the Architect.
- D. New or existing surfaces disturbed as a result of such cutting or otherwise damaged shall be restored to match original work and all materials used for any patching or mending shall conform to the class of materials originally installed.
- E. Refinish surfaces to match adjacent finish. For continuous surfaces, refinish to nearest intersection or natural break. For an assembly, refinish entire unit.

3.14 TEMPORARY FACILITIES

- A. Temporary water facilities, electricity, telephone, toilet facilities, and temporary heat, shall be provided as specified in Division 01.

3.40 PROGRESS MEETINGS

- A. Progress meetings shall be held as specified in Division 01, and also when and if the Contractor or Architect finds them necessary or advantageous to progress of work.
- B. Contractor, those subcontractors and those material suppliers concerned with current progress or with the scheduling of future progress, Architect and Owner shall each be represented at these meetings by persons familiar with the details of work and authorized to conclude matters relating to work progress.

3.82 COMMISSIONING

- A. Comply with requirements of "Commissioning" in Part 1 above.

END OF SECTION 220101

SECTION 220500 - COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Basic material and equipment required for the plumbing equipment and piping work as indicated on the drawings and specified in Division 22.
- B. Other requirements applicable to more than one section of Division 22.
- C. Identification of plumbing systems and equipment.

1.14 RELATED SECTIONS

- A. Division 01 includes sections specifying requirements for LEED rating, and commissioning, and construction waste management.
- B. Project and special warranties: Division 01 and Section 220101.
- C. Operation and Maintenance Manuals: Division 01 and Section 220101.
- D. Painting: Division 09.

1.21 DEFINITIONS

- A. Project correction period: A period after Substantial Completion of the work during which the Contractor shall correct every part of the work found to be not in accordance with the requirements of the contract documents, promptly after receipt of written notice.
- B. Qualified testing agency: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ASTM E 548; and with additional qualifications specified in individual sections; and where required by authorities having jurisdiction, that is acceptable to authorities.
 - 1. NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7.
 - 2. NVLAP: A testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program.
- C. DN: Dimension Nominale, nominal pipe size in millimeters, in accordance with the metric system for construction, Systeme Internationale (SI).
- D. NPS: Nominal pipe size in inches, in accordance with standard U.S. designations for manufactured pipe. Pipe sizes do not change when projects are designed and built in metric units; each size has a consistent name (nominal dimension) in each system.

1.26 DESIGN REQUIREMENTS

- A. The drawings and system performances have been designed based on using the particular manufacturer's products specified and scheduled on the drawings.
- B. Products of other manufacturers that are listed under the article "Acceptable Manufacturers," or permitted as "equal," are permitted provided:

1. Product shall meet the specifications.
 2. Contractor shall make, without addition to the contract sum, all adjustments for deviations so that the final installation is complete and functions as the design basis product is intended.
- C. Do not propose products with dimensions or other characteristics different from the design basis product that render their use impractical, or cause functional fit, access, or connection problems.
- D. The contract drawings are generally diagrammatic and do not indicate all fittings or offsets in pipe, all access panels, or other specialties required.
1. Install pipe exposed to view parallel with the lines of the building and as close to walls, columns, and ceilings as may be practical, maintaining proper clearances for access at all parts requiring servicing.
 2. Install pipe a sufficient distance from other work to permit a clearance of not less than 0.5 inch (15 mm) between its finished covering and adjacent work.
 3. No pipe shall be run below the head of a window or door.
- E. Equipment and pipes installed in areas without a suspended ceiling shall be as tight to structure as possible, but at least above a height of 6'-8", unless otherwise noted.
1. Pull boxes and other appurtenances which require operation or maintenance shall be easily accessible. Do not cut or form handholes for operation or maintenance of appliances through walls or ceilings.

1.30 SUBMITTALS

- A. Comply with Division 01 and Section 220101.
- B. Shop drawings:
1. Showing proposed expansion design.
 2. Schedule of welding and brazing procedures proposed for each piping system included in the project.
- C. LEED submittal:
1. Product data for Indoor Environmental Quality (IEQ) Credit 4.1: For adhesives and sealants, include printed statement of VOC content.
 2. Product data for Indoor Environmental Quality (IEQ) Credit 4.4: For wood products such as plywood equipment backboards, include printed statement of non-urea-formaldehyde component present in material.
- D. Certifications: Proof of operator and testing agency personnel qualifications as required for welding and brazing in the article "Quality Assurance" below.
- E. Test reports: Field test results for each piping system as specified in Part 3 below.

1.40 QUALITY ASSURANCE

- A. Provide materials and perform work in accordance with the plumbing, mechanical, electrical, building, fire, health and safety, and other applicable codes and regulations of the state, county or city in which the work is performed.

1. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.
- B. Welding procedures and operator qualifications for structural welding: AWS D1.1, Structural Welding Code Steel, electric arc process.
- C. Welding, brazing, and soldering procedures and operator qualifications for building systems piping:
 1. AWS D10.9, Qualification of Welding Procedures and Welders for Piping and Tubing.
 2. ASME B31.9, Building Services Piping.
 3. Copper Development Association "Copper Tube Handbook."
 4. Safe Drinking Water Act.
- D. Electrical control panels, equipment, materials and devices provided or installed as work of Division 22 shall bear UL label or, if UL label is not available, the item shall be tested and labeled by a qualified testing agency, acceptable to authorities having jurisdiction, and in accordance with NFPA 70 (NEC). Provide testing, if required, without addition to the contract sum.
- E. Qualifications of DVD documentation technician: For video documentation specified in "Operating Instructions (Demonstration)," employ persons knowledgeable in DVD optical storage media format for video and audio production and editing.
- F. The project shall be LEED certified. See requirements specified in Division 01 and individual sections for LEED requirements, waste and air quality control.
- G. VOC content: Field-applied adhesives and sealants, limits per South Coast Air Quality Management District (SCAQMD), Rule No. 1168.
- H. Products shall contain no urea-formaldehyde content.

1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractors' and subcontractors' responsibilities are described in Division 01.

PART 2 - PRODUCTS

2.10 MATERIALS

- A. General piping techniques, testing, identification, painting, and operating instructions specified in this section apply to products specified in other sections of Division 22.
- B. Weldolets and thredolets: Fittings designed for installing branches on piping, with either welded or threaded connection to branch; conforming to ASTM A 234.
- C. Solder: Free of lead, antimony, and zinc and meeting the requirements of ASTM B 32. No solder containing lead is permitted.
 1. Tin 95.5 percent, copper 4 percent, and silver 0.5 percent; equal to "Silvabrite 100" manufactured by Engelhard Corporation.
 2. Tin, copper, bismuth, and silver; equal to "Oatey Silver" manufactured by Oatey.

- D. Flux: Meeting the requirements of ASTM B 813 and NSF 61 certified, equal to Oatey H-2095.
- E. Pipe jointing compound:
 - 1. Polytetrafluoroethylene (PTFE) pipe thread tape, "Teflon."
 - 2. Pipe cement and oil.
 - 3. For sanitary piping overhead of food storage, preparation, and serving and dining areas: Litharge and glycerine.
- F. Wood-preservative-treated lumber: Treated by pressure process, AWPA C2, with chemicals acceptable to authorities having jurisdiction, and marked with treatment quality mark of an inspection agency approved by ALSC Board of Review.
 - 1. Application: Treat items indicated on the drawings, and the following:
 - a. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, or waterproofing.
 - b. Wood sills, sleepers, blocking, and similar concealed members in contact with masonry or concrete.
 - c. Wood framing and furring attached directly to the interior of below-grade exterior masonry or concrete walls.
 - d. Wood framing members that are less than 18 inches (460 mm) above the ground in crawlspaces or unexcavated areas.
 - e. Wood floor plates that are installed over concrete slabs-on-grade.

2.12 MATERIALS FOR BACKBOARDS FOR PIPING SPECIALTIES

- A. Provide wall-mounted backboards for mounting piping specialties consisting of plywood board, supports, and fasteners.
 - 1. Backboard: Moisture-resistant marine plywood, locations and sizes as indicated on the drawings.
 - 2. Supports: Vertical backing rails, corrosion resistant, consisting of FRP composite structural shapes as indicated on the drawings.
 - 3. Fasteners: Corrosion-resistant fasteners suitable for secure anchorage into wall construction behind backboards.
- B. Marine plywood: BS-1080, Veneer Grade A/B, moisture-resistant marine plywood, spruce-pine-fir multiple ply, 5-ply minimum, pressure-treated construction, 0.563-inch (14-mm) thick minimum
- C. Fiber reinforced plastic (FRP) composite structural shapes: ASTM D 635 and E 84, Pultruded FRP structural shapes, non-corrosive, flame retardant, thermosetting polyester resin, composite factory-fabricated shapes for assorted assemblies and field erection.
 - 1. Ultimate tensile strength: 30,000 psi (207 MPa).
 - 2. Modulus of elasticity: 2.8×10^6 psi (19,300 MPa).
 - 3. Specific gravity: 1.6 to 1.75.
 - 4. Density; 0.062 to 0.070 pounds/cubic inch (1.72 to 1.94 grams/cubic centimeter).
 - 5. Flame spread: ASTM E 84 Class A, 25 maximum.
 - 6. Color: Yellow.
 - 7. Shapes and sizes as indicated on the drawings
 - 8. Submit shop drawings of assemblies.
 - 9. Acceptable manufacturers:

- a. Bedford Reinforce Plastics Company
- b. Composites USA, Inc.
- c. Liberty Pultrusions, Inc.
- d. Strongwell Corporation
- e. Structural Fiberglass, Inc.
- f. Or approved equal.

2.21 IDENTIFICATION DEVICES AND MATERIALS

A. Stenciling materials:

1. Stencils: Manufactured standard stencils prepared for required applications, conforming to ANSI A13.1 for color and size of legend letters, including arrows showing direction of flow.
2. Paint: Exterior type enamel, colors conforming to ANSI A13.1, or black.

B. Equipment identification tags:

1. Laminated plastic with adhesive back, white core and black outer layers, which, when engraved, will produce white letters and numerals on a black background.
2. Tags installed on curved surfaces shall be aluminum or brass.

C. Valve tags: Brass, 1.5 inch (40 mm) in diameter with black-filled numbers not less than 0.25 inch (6 mm) high, complete with brass attachment chains.

D. Ceiling identification tags: Laminated plastic with adhesive back, engraved black letters on white background, minimum 0.5 inch (15 mm) wide and length as required for 0.375 inch (10 mm) high letters for name of concealed device and number.

2.23 DATE-SENSITIVE EQUIPMENT

A. Date-sensitive equipment: Systems, equipment, or components which use or process date and time data in order to perform their functions.

B. Each item of date-sensitive equipment used in the project shall be warranted by the manufacturer to properly function and correctly use or process all time-related data for all dates and times which occur during a reasonable life expectancy of the equipment.

PART 3 - EXECUTION

3.03 INSTALLATION OF PRODUCTS AND EQUIPMENT

A. Manufacturers' instructions: Except as modified by drawings or specifications, install products and equipment in accordance with manufacturers' instructions and recommendations applicable to the project conditions.

1. Immediately notify Architect if a difference or discrepancy is found between manufacturers' instructions and the drawings or specifications.

3.22 PIPE INSTALLATION

A. Remove burrs resulting from cutting pipe or from any other operation.

B. Threaded connections:

1. Cut threads full and clean.
 2. Apply specified pipe jointing compound or tape on male threads only.
 3. Where piping is installed in crawl spaces and tunnels, cover exposed threads with either bituminous protective coating or rust-inhibitive paint. Apply after joints have been assembled and tested.
- C. Thoroughly clean pipe and fittings before they are installed, and keep them clean until the acceptance of the completed work. Cap or plug the ends of the lines so as to prevent earth and other debris from entering during construction.
- D. Provide for expansion and contraction of piping and connections so that no strain or breakage will occur. Provide anchors and guides of approved design where shown on drawings and where necessary to allow for proper expansion and contraction. At the time of installation, expansion loops shall be cold sprung to one-half of the calculated expansion.
- E. Provide for draining all parts of water piping systems and apparatus by installing a valved hose connection at every low point.
- F. Black steel piping NPS 2.5 (DN 65) and larger shall be welded; NPS 2 (DN 50) and smaller shall be threaded, except as required otherwise in a particular section.
- G. Each connection from risers to equipment shall contain at least three elbows or expansion joints. Connections shall be so arranged that movement in piping due to expansion and contraction will not be transmitted to the equipment.
- H. Install unions and flanges in the piping at each item of equipment, control valve, and appliance, so as to provide easy removal of the equipment, valve, or appliance.
- I. Pitch water piping so that air in the system can be properly vented. Provide stop valves where necessary to isolate parts of system for repairs without draining the entire system.
- J. Special techniques: Follow the techniques for soldering and brazing pipe, fittings, and valves as recommended by the manufacturer.

3.23 COPPER TUBING FOR WATER INSTALLATION

- A. Solder joints for copper tubing: Clean ends of tubing and inside of fitting ends thoroughly with emery cloth before applying flux.
- B. Make flare joints in copper tubing with proper size flaring tool and in accordance with manufacturer's recommendations.
- C. Provide isolation fittings between copper and steel piping to prevent electrolysis.
- D. Cut pipe with a tubing cutter or fine-tooth saw. Cuts made with a saw shall be true and square, and the end shall be filed smooth with a fine-tooth file. Remove all marks and burrs with sandpaper.

3.24 PLASTIC PIPING INSTALLATIONS

- A. Cut pipe true and square with a fine-tooth saw and file the end smooth with a fine-tooth file. Remove all saw marks and burrs with sandpaper.
- B. Clean connecting surfaces of both pipe and fitting with methyl ethyl ketone or acetone.

- C. Apply solvent cement liberally with clean brush, first to fitting and then to pipe (outer surface and end). Lap cement a minimum of 0.25 inch (6 mm) over depth of fitting.
- D. Join pipe and fitting to full depth of fitting, giving fitting at least one-quarter turn on pipe to distribute cement.
- E. Pipe and fitting shall show a small fillet or bead completely around pipe without any voids, or fitting shall be cut out and new fitting made up and installed. Allow a minimum of 48 hours drying time for each joint.

3.25 INTERFACE WITH OTHER PRODUCTS

- A. Where it is necessary to run pipes through walls, provide finished, permanent, waterproof installation complete with inserts, sleeves, supports or hangers, seals, and other appurtenances as required. Do not pierce, cut, or notch any footing or other structural member.
- B. Waterproofing and dampproofing of the building shall be unharmed by the installation of the work. Where pipe has to pierce waterproofing or dampproofing, including outside walls, the penetration shall be made watertight. Waterproofing damaged or destroyed shall be repaired or replaced with new waterproofing.

3.59 IDENTIFICATION

- A. General: Do not apply identification until insulation and finish painting work is complete.
- B. Equipment:
 - 1. Stencil equipment with minimum two-inch (50-mm) -high letters or provide identification tags. Clearly identify function, equipment served, and area served.
 - 2. Firmly fasten each identification tag to its appropriate piece of equipment with drive screws, sheet metal screws, or rivets. Do not interfere with operation of, or damage the item being marked.
- C. Piping:
 - 1. Mark by stenciling.
 - 2. Mark to identify service with arrows showing direction of flow. Apply markings near building walls where pipes enter or leave an accessible space and in intermediate locations so that markings are no more than 30 feet (9 m) apart. They shall be readily visible to a person standing on the floor.
 - 3. Fully identify all piping installed as work of the project.
 - 4. Mark pipe with letters of height and with colors as required by OSHA and conforming to ANSI A13.1.
 - 5. Identify every thermometer, gage, and control device.
 - 6. Provide valve tags for all valves except stop valves on individual fixtures or equipment where their function is obvious, or where the fixture or equipment is immediately adjacent. Numbers shall correspond to those shown on the Valve Chart. Attach tags to valve shaft.
- D. Ceiling identification tags: Provide on the access door or, in suspended ceilings, on the ceiling support adjacent to the unit.
 - 1. Valves: Identify with the same number shown on the valve tag.

3.61 PIPING TESTS

- A. Notify Owner at least one day prior to the actual test.
- B. Test before pipes are concealed or insulated. Test the piping in sections as the work progresses, so as not to delay progress of the building construction. Furnish pumps and gages required for testing.
- C. Conduct piping tests before connecting equipment that would be subject to damage from the test pressure. Replace piping or fittings found defective with new material.
- D. Bracing and supporting: Adequately brace and support piping during the test, so that no movement, displacement, or damage results from the application of the test pressure.
- E. Interior sanitary and storm drainage piping:
 - 1. Before connection of the plumbing fixtures and before connection to the sewer, cap or plug the entire sanitary, condensate, and storm drainage piping systems of the building.
 - 2. Test following the methods of testing required by the plumbing code, and no less than the duration and pressures required in the Schedule of Piping Systems Tests.
 - 3. Where pipes are in trenches, leave the trenches open until the completion of the test.
- F. Test exterior gravity sanitary and storm sewer piping by the exfiltration method. Backfill over sewers to a minimum depth of two feet of cover prior to tests. Plug the lower manhole, filling the section between manholes with water and measuring the drop in water level in the upper manhole. Furnish water for testing, and maintain it at levels directed by the Architect, for a period of at least 24 hours. Repair or replace all visible leaks and all defects to meet the maximum allowable leakage shown in the Sewer Piping Test Schedule at the end of this section.
- G. Test the piping systems for not less than four hours to fulfill the conditions in the Piping Systems Test Schedule at the end of this section.
- H. Documentation of tests: Prepare a test report for each portion of piping tested, identified by service, material, location, and pipe size. Include these items:
 - 1. Date of test.
 - 2. Starting and completion times.
 - 3. Initial test pressure.
 - 4. Final test pressure.
 - 5. Problems or leaks detected.
 - 6. Corrective actions taken.
 - 7. Record of successful completion of testing.
 - 8. Name, title, and signature of person conducting test.

3.75 CLEANING AND PAINTING

- A. Cleaning: Clean all piping and equipment. Where items are to be painted, clean ready for painting.
- B. Painting: Coordinate painting with requirements of Division 09. Paint the items identified below to be painted. Use paint materials and systems specified in Division 09.
- C. Items to be painted:

1. Items identified below to have protective coating.
 2. Items furnished with manufacturer's prime coat.
 3. Mechanical rooms:
 - a. Insulation and uninsulated steel: Piping, pumps, tanks, and vessels.
 - b. Hangers and supports.
 4. Piping exposed in finished spaces, insulated and uninsulated.
- D. Items not to be painted: Copper, stainless steel, and equipment furnished with manufacture's finish.
- E. Paint systems in mechanical rooms: Paint piping using colors in accordance with ANSI A13.1.
1. Galvanized steel: One coat of primer recommended for galvanized surfaces and one coat of glossy alkyd enamel.
 2. Ferrous metal: One coat of primer recommended for ferrous metal and one coat of glossy alkyd enamel.
- F. Paint systems for exposed piping: Primer compatible with the substrate, whether steel, galvanized steel, insulation jacket, or other material; one coat or two, if required to cover, to match adjacent surfaces in color and texture.

3.81 OPERATING INSTRUCTIONS (DEMONSTRATION)

- A. Furnish the necessary technicians, skilled workers, and helpers to operate all the plumbing systems and equipment of the entire project for one 8-hour day.
- B. Where specified in technical sections, provide longer periods required for specialized equipment.
- C. Instruct the Owner or designated personnel in operation, maintenance, lubrication, and adjustment of all systems and equipment.
 1. Instructions by manufacturer's technical representative for each type of equipment shall include the performance of the recommended preventive maintenance procedures for that equipment.
- D. The Operating and Maintenance Manual shall be available at the time of the instructions, for use by instructors and Owner personnel.
- E. Record each instruction session only in DVD media format (video and audio format), including both the sessions specified above and added sessions required in technical sections for specialized equipment. Provide one complete set of DVDs with each Operating and Maintenance Manual.
- F. Schedule the general and specialized instruction periods for a time agreed upon by the Owner and Architect.

3.90 SCHEDULES

- A. Sewer Piping Test Schedule:

<u>Dia. of Sewer</u> in (mm)	<u>Leakage</u> Gal/100 ft./24 hrs (L/M/24 hrs)
6 (150)	76 (9.4)
8 (200)	95 (11.8)
10 (250)	114 (14.1)
12 (300)	133 (16.5)

B. Piping Systems Test Schedule:

SYSTEM	TEST PRESSURE PSIG (kPa)	ALLOWABLE DROP	MEDIUM
Domestic water service and exterior water piping	150 (1030)	None	Water
Domestic water, cold & hot, and recirculated	125 (860)	None	Water
Air conditioning condensate drain	4.3 (30)**	None	Water
Sanitary waste	4.3 (30)**	None	Water
Storm	4.3 (30)**	None	Water

** Where piping is above food service area, test pressure shall be 11 psig (76 kPa).

END OF SECTION 220500

SECTION 220501 - EXCAVATION AND FILL FOR PLUMBING WORK

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Trenching, backfilling, and compacting for plumbing work underground inside the building and extending five feet beyond exterior building walls, and outside the building as shown on drawings.
- B. Restoring and reseeding grassed areas.

1.14 RELATED SECTIONS

- A. Cutting and patching: Division 01 and Section 220101.
- B. Repairing pavements: Division 32.
- C. Piping: Sections 211000, 221116, 221316, and 221413.

1.20 REFERENCES

- A. ASTM D 1557: Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbs/cu ft (2700 kN-m/cu m).

1.30 SUBMITTALS

- A. General: Submit in accordance with Division 01 and Section 220101.
- B. Shop drawings: At the same scale as the contract drawings, showing field verified locations of utilities, and proposed detailed trenching plan.
- C. Product data:
 - 1. Warning tape
 - 2. Seed and mulch
- D. Certifications: Test reports showing that compaction meets specified requirements.

PART 2 - PRODUCTS

2.10 MATERIALS

- A. Backfill: Earth materials, free from perceptible amounts of wood, debris, or topsoil, free of frost at the time of placement, and not containing marl or other elements which tend to stay in a plastic state.
- B. Underground warning tape: Polyethylene 0.004 inch (0.102 mm) thick for metallic lines, and for non-metallic lines polyethylene both sides with metallic lining, six inches (152 mm) wide.
 - 1. Colors: In accordance with APWA and AASHTO standards.
 - 2. Markings: Repeated continuously along the entire length, legend appropriate for line being identified.

- C. Grass seed: Fresh new-crop seed, 90 percent pure and 85 percent germination. Mix: 70 percent Kentucky Bluegrass, 25 percent Red Fescue and 5 percent Red Top. Only strains of Kentucky Bluegrass found adaptable to Maryland shall be acceptable.
- D. Mulch: Free of sticks, weeds, or other foreign matter; either licorice root, tan root, or tan bark; fibrous by-product of extraction. Use only one type throughout the project.

2.12 EQUIPMENT

- A. Mechanical tampers for compacting backfill: Capable of exerting a blow equal to 250 pounds per square foot (12 kPa) of area of the tamping face.

PART 3 - EXECUTION

3.05 PREPARATION

- A. Contact local utility company underground information service (BGE Miss Utility) before beginning excavation outside buildings.
- B. The general locations of underground utilities are indicated on the drawings and are not to be assumed to be accurate or complete. Before beginning work, field check the area with the most accurate instruments available, such as Fisher Labs' Pipe and Cable Locators.

3.20 INSTALLATION

- A. Perform all excavating, cutting of paved areas, trenching, sheeting, shoring, backfilling, and compacting required for the proper installation of the work. Repair of pavement is specified in Division 32.
- B. Where obstructions are encountered, obtain written approval and make necessary changes in line, grade or location.
- C. Protect existing utilities from damage during excavation and backfilling. Repair damaged new or existing work at no addition to the contract sum. Bracing, shoring and other protection of existing utilities is part of this work.
- D. Do not damage or remove existing shrubs or trees including their root systems, without prior notification to the Architect.
- E. Provide temporary roadways over trenches with railings and other safeguards, including amber blinker lamps or other warnings for night use.
- F. Note the depths of footings. In cases where piping is in close proximity to or below footings and where the natural earth under footings is disturbed, after the line is installed the voids shall be filled up to bottoms of such footings with solid concrete.

3.24 CUTTING

- A. Cut concrete and asphalt concrete with masonry saw prior to breaking it into smaller pieces for removal.
- B. Cut sidewalks perpendicular to the length at the closest existing joint that is a minimum of 24 inches back from either side of the top of the new trench.

3.25 TRENCHING

- A. Excavations inside the building shall be carefully planned. Stockpile excavated earth so as not to interfere with other construction. Dig trenches to the proper depths, providing extra depressions where required for hubs of pipes.
- B. Excavations outside the building shall generally follow the routes indicated on the drawings. Stockpile topsoil separately for later replacement. Excavations shall be of sufficient depths to provide, unless indicated otherwise on the drawings, a minimum cover as follows:
 - 1. Water piping: 42 inches (1067 mm).
 - 2. Sewer lines: Elevations shown on drawings.
- C. Trenches shall be of necessary depth and width for the proper laying of pipe with a minimum of 8 inches (205 mm) on each side of the joint.
 - 1. The sides shall be as nearly vertical as practicable. Unless local regulations are more strict, trenches 4 ft. (1220 mm) and deeper shall have shored sides as required by OSHA trenching regulations.
 - 2. The bottoms of trenches shall be accurately graded to provide uniform bearing and support for each section of pipe on undisturbed soil at every point along its entire length, except for bell holes and for the proper sealing of the pipe joints.
 - 3. No greater length of trench shall be left open, in advance of the completed structure placed in it, than can be completed in that day's operation.
 - 4. Except where rock is encountered, do not excavate below the depths required. Where rock excavation is required, excavate to a depth of at least 6 inches (150 mm) below the trench depth and fill the overdepth with compacted crusher run or bank run stone or sand. Unauthorized overdepths in excavation shall be backfilled with crushed stone, slag or gravel, thoroughly compacted.
 - 5. Whenever wet or otherwise unstable soil is encountered, it shall be removed to the depth and extent directed, and the trench backfilled to the proper grade with crushed stone, slag or gravel.
- D. Should springs be encountered within the work area, or soft soil conditions at the elevations required for load bearing, immediately notify the Architect and do not place any portion of the work on such surfaces until instructions are received.
- E. Furnish and maintain pumps, flumes, gutters, and appurtenances if required to keep the excavations free from water. Water shall be directed to a point remote from building operations, shown on the approved shop drawing.
- F. Excavation for manholes and similar structures shall be sufficient to leave a minimum of 12 inches (305 mm) and a maximum of 24 inches (610 mm) clearance on all sides. Fill over-depth excavation with concrete.

3.26 BACKFILL

- A. Place no backfill until the adjacent construction or the utility to be covered has been inspected, tested, and approved.
- B. Installing underground warning tape: Install in backfill above exterior buried lines not encased in concrete. Select legend and color appropriate for type of line. Install metallic lined tape for non-metallic lines. Install approximately 12 inches (305 mm) below grade.

C. Plumbing systems backfill:

1. Backfill and compact in six-inch (150-mm) layers up to spring line of the pipe. The installations shall then be inspected and tested.
2. Following inspection, backfill in six-inch (150-mm) layers, each compacted, until the pipe has a cover of not less than one foot (305 mm). Place the remainder of the backfill material in the trench in eight-inch (200-mm) compacted layers.
3. Excavations improperly backfilled shall be reopened, then refilled and compacted to the required grade and compaction, and smoothed off.
4. Open trenches across roadways or other areas to be paved shall be backfilled as specified above, except that the entire depth of trench shall be backfilled in six-inch (150-mm) layers, and each layer shall be mechanically compacted.
5. Completed work shall have uniform graded surface, in accordance with the surface and grade indicated on the drawings.

D. Structure backfill:

1. Do not backfill against structures with cement mortar joints until the mortar is at least twelve hours old.

3.27 COMPACTION

- A. Test in accordance with the requirements of ASTM D 1557.
- B. Compact under slabs, roads, and sidewalks to a 95 percent density.
- C. Compact unpaved areas to a 90 percent density.
- D. Backfill and compact trench in unpaved areas to within 4 inches (102 mm) of existing grade. Furnish and install compacted select topsoil for the final layer to finish even with existing grade. Remove surplus earth and rake unpaved areas for final planting.
- E. Take particular care in compaction of earth under joints of plumbing piping.

3.28 SEEDING

- A. Seed disturbed grass areas at the rate of 5 pounds (2.27 kg) per 1000 sq. ft. (92.9 sq. m), with the seed mix specified.
- B. Uniformly distribute seed with an approved machine to ensure a covering of plus or minus 0.25 inch (6 mm). Sow half of the seed in one direction and the rest at right angles.
- C. Do not seed during windy weather or when ground is wet or otherwise untillable. Seed between the dates of March 1st to May 1st or August 15 to October 15 unless otherwise approved in writing.

3.29 MULCHING

- A. Mulch seeded areas immediately following seeding with fibrous mulch evenly applied at an average rate of 2 tons per acre (4483 kg per hectare) so as to provide a loose depth of not less than 2 inches (50 mm).
- B. Wet down mulch, unless a heavy rain wets it, to the Architect's satisfaction, immediately after application.

3.41 RESURFACING

- A. Resurface sidewalks, roads, streets, and other paved areas as work of this section, matching the construction and finish of adjacent paving. Paving shall meet the requirements of Division 32.

END OF SECTION 220501

SECTION 220502 - SLEEVES AND PLATES FOR PLUMBING PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Sleeves and escutcheon plates for piping systems.
- B. Mechanical seals for piping penetrations.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Product data: Sleeves, plates, sealants, and mechanical penetration seals.

PART 2 - PRODUCTS

2.10 SLEEVES, PLATES, AND ACCESSORIES

- A. Steel sleeves: Schedule 40 black steel pipe, ASTM A 53.
- B. Copper sleeves: Type L, ASTM B 88 hard drawn.
- C. Cast-iron sleeves: Extra heavy, equal to product of U.S. Pipe Co. with waterstop and ends as shown on the drawings.
- D. Plastic sleeves: Schedule 40 PVC, ASTM D 1785.
- E. Sealing compound in walls and floors: Equal to the following:
 - 1. Bare and insulated pipes carrying fluids 150 degrees F (65 degrees C) and below: Sika Corporation "Sikaflex – 1a." Use a primer for applications required by the manufacturer.
 - 2. Bare and insulated piping carrying fluids 151 degrees F (66 degrees C) and above: Dow Corning Corporation "795 Silicone." Use a primer for applications required by the manufacturer.
- F. Floor, wall and ceiling plates: Stamped or cast brass, hinged type as pipe size requires. Plates shall have chrome finish.
- G. Mechanical penetration seals: Equal to PSI "Link-Seal Modular Seals" or Calpico Sealing Link "LINX". Seals shall be modular mechanical type, consisting of interlocking synthetic links shaped to continuously fill the annular space between the pipe and wall opening. Bolt and nut fasteners for the seals shall be stainless steel for units used in penetrations below grade.

PART 3 - EXECUTION

3.20 INSTALLING SLEEVES

- A. Install sleeves for piping, or piping with insulation continuous through sleeve, passing through walls, partitions, beams, or slabs.
- B. Do not cut, drill, or burn structural steel for installation of piping without specific instructions from the Architect.

C. Locations in nonfire-rated construction:

1. Install steel sleeves for penetrations of steel, iron, and insulated piping.
2. Install copper sleeves for penetrations of uninsulated copper tubing and piping.
3. Install plastic sleeves for penetrations of plastic piping. Plastic piping and sleeves are not permitted in ceiling spaces used as HVAC system plenums, or in shafts used for building HVAC air distribution.

D. Locations in floors and fire-rated construction: Sleeves used in piping penetrations through fire-rated construction shall be an acceptable component of the through-penetration firestop assembly as specified in Section 220507, Firestopping for Plumbing Work.

1. Where firestop assembly is UL listed, sleeve material shall be as directed in the listing.
2. Where other specified approval and acceptance is required, sleeve shall be as described in the approved assembly.

E. Install sleeves through walls and partitions flush with finished surfaces.

F. Sleeves through floors shall extend 0.375 inch (10 mm) above top of finished floor and be finished neat and level. Sleeves through mechanical or equipment room floors shall extend one inch (25 mm) above finished floor. Provide projecting sleeves with anchor clips to prevent them from being loosened and knocked down in the floor construction.

G. Sleeves for penetrations in kitchen and food service areas shall finish 0.375 inch (10 mm) above floor or flush with wall surfaces and be neatly pointed up to fit snugly against floor or wall materials. Seal space between pipe and sleeve with waterproof sealant or fire barrier as required, and finish even with wall or floor with a light pouring of molten lead.

H. Sleeves for insulated piping shall be large enough to pass piping and insulation.

I. Seal spaces between sleeves and pipe, or pipe insulation, in nonrated walls, with mineral wool.

J. Penetrations in exterior masonry or concrete walls and foundations:

1. Sleeves: Cast iron, or in cast concrete may be core drilled.
2. Above and below grade: Mechanical penetration seal, at outside face of wall.

3.25 INSTALLING PLATES

A. Piping passing through interior walls, partitions, floors, and ceilings in exposed locations shall be fitted with wall, floor, and ceiling plates of size and depth to conceal sleeves. Secure plates firmly in place with set screws.

B. Do not install floor or wall plates on pipes in the kitchen and food service areas.

END OF SECTION 220502

SECTION 220503 - ACCESS DOORS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Access doors for concealed plumbing specialties requiring maintenance or manual operation.

1.14 RELATED SECTIONS

- A. Valves: Section 220523.
- B. Specialties: Section 221119, 221319 and 221423.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Product data: Each type of access door.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Wall and ceiling access doors:
 - 1. Cesco Products Company
 - 2. Karp Associates, Inc.
 - 3. Milcor, Inc.
 - 4. Zurn Industries

2.21 WALL AND CEILING ACCESS DOORS

- A. Doors: Provide Milcor model listed, or similar type and equal quality by another acceptable manufacturer.
- B. Types:
 - 1. Fire-rated where occurring in fire-rated walls.
 - 2. Style AP where occurring in acoustical plastered surfaces.
 - 3. Style K where occurring in hard plastered surfaces.
 - 4. Style MS stainless steel where occurring in masonry or ceramic tile surfaces.
 - 5. Style DW where occurring in drywall construction.
- C. Sizes: As required for access to the particular device, but no less than 16 by 16 inches (405 by 405 mm).
- D. Finish: Brushed stainless steel.

2.70 LABELS

- A. For access doors to fire protection devices: OSHA and NFPA approved, describing the fire protection device within.

- B. Minimum lettering size: 0.5 inch (13 mm) high.

PART 3 – EXECUTION

3.20 INSTALLATION

- A. Provide access doors in walls and inaccessible ceilings for plumbing devices, valves, and other concealed specialties and appliances that require manual operation or maintenance.
- B. Select appropriate size door for each particular application.

END OF SECTION 220503

SECTION 220505 - EQUIPMENT CONNECTIONS FOR PLUMBING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Equipment connections for plumbing, to food service equipment.

1.14 RELATED SECTIONS

- A. Piping connections: Section 220500.
- B. Rough-in dimensions and lists of accessories: Suppliers of equipment specified in other divisions.
- C. Schedule of roughing-in and connections: Drawings.
- D. Wiring connections: Section 260521.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Product data: Any product required for connection but not specified in other sections.
 - 1. Certification that products comply with NSF/ANSI 61 and NSF/ANSI 372.

1.40 QUALITY ASSURANCE

- A. Potable water system components intended to dispense water for human consumption, including pipe and joining materials, shall comply with the following:
 - 1. A weighted average lead content of not more than 0.25 percent as determined by NSF/ANSI 372.
 - 2. NSF/ANSI 61.
- B. Acceptance product marking: NSF®-61 and NSF®-372 (or NSF®-61-G) or other accepted certifier marks demonstrating third party certification with these requirements.
- C. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.

PART 2 - PRODUCTS

2.10 MATERIALS

- A. Traps NPS 2 (DN 50) and larger shall be galvanized cast iron P traps. NPS 1.5 (DN 40) P traps shall have cleanout plug and chrome finish. Those concealed within base cabinets of equipment may be rough brass.
- B. Solids interceptor (sediment trap): Zurn Series ZA-1180, as specified in Section 224200.
- C. Shutoff valves for plumbing fixtures:

1. Rough brass, equal to Nibco Inc. No. 726-LF.
2. Exposed: Chrome-plated, equal to Chicago Faucet Co. No. 45-LKABCP.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Rough in and connect to plumbing equipment. Install valves, balancing cocks, thermometer wells, gage tappings, control valves, air vents, traps, strainers, drains, and appurtenances as shown on diagrams on drawings and specified under other sections of the specifications.
- B. Rough in and connect to food service, sinks, and other equipment requiring water, drain, or other piping connections, that is specified, furnished and set in place in other divisions or listed in the Schedule of Roughing-in and Connections on the drawings.
 1. Faucets, drains, trim, and necessary vacuum breakers, solenoid valves, flow control fittings supplied with the sinks and equipment are specified herein or under other divisions.
 2. Rough-in dimensions and list of accessories shall be provided by the equipment supplier.
- C. Install the faucets, drains, trim, and accessories and provide necessary supply stops, P traps, and shock absorbers with necessary fittings to make a complete and satisfactory installation of every item of equipment.
- D. Provide water supply shutoff valves, and unions at each item of equipment. Where exposed adjacent to chromium-finished piping, the water shutoff valves shall be chromium plated.

END OF SECTION 220505

SECTION 220506 - CURBS AND FLASHINGS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Pipe boot assemblies and flashing devices for plumbing items and equipment penetrating roof and mounted on roof.

1.14 RELATED SECTIONS

- A. Rough carpentry: Division 06.
- B. Piping: Sections 221116, 221316, and 221413.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Shop drawings: Flashing assemblies and devices showing compatibility with roof membrane, insulation, and slope, and configuration for the supported equipment.
- C. Product data: Each type of manufactured unit, accessory, and accessory material.

PART 2 - PRODUCTS

2.10 MATERIALS

- A. Wood-preservative-treated lumber: As specified in Division 06 and in Section 220500.
 - 1. Application: Treat items indicated on the drawings, and the following:
 - a. Wood cants, nailers, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, or waterproofing.

2.20 PENETRATIONS OF SINGLE PIPE OR VENT

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified product, or comparable product by another manufacturer.
- B. Plumbing vents through flat roof: Equal to Elmdor/Stoneman 1100-4, 4-lb (1.8 kg per 0.09 sq. m) seamless lead flashing assembly, 8-inch (205-mm) skirt, vandalproof hood, top counterflashing fitting, and waterproofing compound.
- C. Plumbing vents on sloped roofs: Equal to Oatey Flashings type "Hi Collar Lead Flashing" with base size 15 by 15 inch (380 by 380 mm); weight of lead, 4 lbs (1.8 kg per 0.09 sq. m); angle of roof as shown on the drawings. Flashing shall be formed to fit over top of pipe and in one continuous piece down to roof.
- D. Boot for water piping through flat roof: Equal to Elmdor/Stoneman 1100-4, 4-lb (1.8 kg per 0.09 sq. m) lead boot, 8-inch (205-mm) skirt; top counterflashing fitting and waterproofing compound.

2.21 PENETRATIONS OF GROUPS OF PIPES

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified product, or comparable product by another manufacturer.
- B. Where a group of pipes penetrates the roof, provide a curb assembly equal to RPS Corporation Style RC. Assembly shall include curb, cover, and boots and clamps for the number of lines shown on the drawing. Curb shall be a minimum of 18-gage galvanized steel, unitized construction with integral base plate insulated with 3-pound (48 kg/m³) density insulation, 2 by 2 inch (50 by 50 mm) nailer, acrylic-clad ABS plastic cover, and fastening screws. Boots shall be graduated step design EPDM rubber, with stainless-steel lock clamps.

2.72 ROOFTOP PIPE SUPPORT SYSTEM

- A. Equal to Caddy "Pyramid ST" Series PSF, UV-stabilized; polyethylene, polypropylene, and hot-dip galvanized strut-based support, 10 inches minimum strut length by 4.8 inches in height.
- B. Provide manufacturer's standard pipe clamps and accessories designed for strut system, as required for size, material, and configuration of air-conditioning condensate lines across roof.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Plumbing vent shall extend 8 inches (205 mm) above finished roof. Clamp devices shall be tightly sealed to vent. Space between vent hub and pipe shall be lightly caulked with lead to provide for movement in piping.
- B. Flashing of roofing felts into clamping devices of roof drains and sleeves through roof, and flashing and counterflashing of pipe curb assemblies and of roof rails and curbs shall be as specified under Division 07.
- C. Where dissimilar metals would come in contact with each other, coat them with bituminous protective coating or other coating compatible with adjacent materials.

3.22 INSTALLING ROOFTOP PIPE SUPPORT SYSTEM

- A. Where air-conditioning condensate lines cross roof from equipment to drain, support on rooftop support system.
- B. Use clamps and fasteners compatible with piping.
- C. Follow manufacturer's instructions.

END OF SECTION 220506

SECTION 220507 - FIRESTOPPING FOR PLUMBING WORK

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Through-penetration firestopping in fire-rated construction.
- B. Through-penetration smoke-stopping in smoke partitions.

1.14 RELATED SECTIONS

- A. Sections specifying requirements for LEED rating are specified in Division 01.
- B. Sleeves and plates: Section 220502.

1.20 REFERENCES

- A. Underwriters Laboratories
 - 1. UL Fire Resistance Directory.
 - 2. UL 1479: Through Penetration Firestops.
- B. American Society for Testing and Materials Standards:
 - 1. ASTM E 814: Standard Test Method for Fire Tests of Through-Penetration Firestops.

1.21 DEFINITIONS

- A. Assembly: Particular arrangement of materials specific to given type of construction described in referenced documents.
- B. Barriers: Time-rated fire walls, smoke barrier walls, time-rated ceiling/floor assemblies and structural floors.
- C. Firestopping: Methods and materials applied in penetrations and unprotected openings to limit spread of heat, fire, gasses and smoke.
- D. Penetration: Opening or foreign materials passing through or into barrier or structural floor such that full thickness of rated materials is not obtained.
- E. Sleeve: Metal fabrication or pipe section extending through thickness of barrier and used to permanently guard penetration. Sleeves are described as part of penetrating system in other sections and may or may not be required.
- F. System: Specific products and applications, classified and numbered by the rating agency to close specific barrier penetrations.

1.25 SYSTEM DESCRIPTION

- A. Design requirements
 - 1. Fire-rated construction: Maintain barrier and structural floor fire resistant ratings including resistance to cold smoke at all penetrations.

2. Smoke barrier construction: Maintain barrier and structural floor resistance to cold smoke at all penetrations.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. LEED submittal:
 1. Product data for Indoor Environmental Quality (IEQ) Credit 4.1: For penetration firestopping, including printed statement of VOC content and chemical components.
- C. Product data: Manufacturer's specifications and technical data including the following:
 1. Detailed specification of construction and fabrication.
 2. Manufacturer's installation instructions.
- D. Shop drawings: Submit firestop assemblies and devices for all openings and through penetrations in fire-rated construction. Indicate dimensions, description of materials and finishes, general construction, specific modifications, component connections, anchorage methods, hardware, and installation procedures, plus the following specific requirements.
 1. Details of each proposed assembly identifying intended products and applicable rating agency classification.
 2. Manufacturer or manufacturer's representative shall provide qualified engineering judgments and drawings relating to conditions where rated assemblies do not exist.
- E. Quality control submittals:
 1. Statement of qualifications.
- F. Applicators' qualifications statement:
 1. List past projects indicating required experience.
- G. Certifications: Letters or forms showing acceptance by local authorities for systems without acceptance by a rating agency.

1.40 QUALITY ASSURANCE

- A. Products and assemblies shall be tested and labeled by an independent, nationally recognized testing and labeling authority.
- B. Comply with requirements for LEED certification specified in Division 01.
- C. Installer's qualification: Firm experienced in installation or application of systems similar in complexity to those required for this project, plus the following:
 1. Acceptable to or licensed by manufacturer, state, or local authority where applicable.
 2. At least 2 years' experience with systems.
 3. Successfully completed at least 5 projects of comparable scale, using these systems.
- D. Local and state regulatory requirements: Obtain acceptance for proposed assemblies not conforming to specific rating agency classifications or rated assemblies.

- E. Materials shall have been tested to provide fire rating at least equal to that of the construction in which they are to be installed.
- F. VOC content: Field-applied adhesives and sealants, limits per South Coast Air Quality Management District (SCAQMD), Rule No. 1168.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Packing and shipping:
 - 1. Deliver products in original unopened packaging with legible manufacturer's identification.
 - 2. Coordinate delivery with scheduled installation date, allow minimum storage at site.
- B. Storage and protection: Store materials in a clean, dry, ventilated location. Protect from soiling, abuse, moisture and freezing when required. Follow manufacturer's instructions.

1.60 PROJECT CONDITIONS

- A. Existing conditions:
 - 1. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding.
 - 2. Proceed with installation only after penetrations of the substrate and supporting brackets have been installed.
- B. Environmental requirements:
 - 1. Furnish adequate ventilation if using solvent.
 - 2. Furnish forced-air ventilation during installation if required by manufacturer.
 - 3. Keep flammable materials away from sparks or flame.
 - 4. Provide masking and drop cloths to prevent contamination of adjacent surfaces by firestopping materials.
 - 5. Comply with manufacturing recommendations for temperature and humidity conditions before, during and after installation of firestopping.

1.80 WARRANTY

- A. General project warranty and correction period, as required in general conditions and Division 01, requires repair or replacement of materials or systems which fail in joint adhesion, co-adhesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, or general durability or appear to deteriorate in any other manner not clearly specified by submitted manufacturer's data as an inherent quality of the material for the exposure indicated.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers and products: Those listed in the UL Fire Resistance Directory for the UL System involved, or rated for the application by Warnock Hersey or by another acceptable rating agency.

2.20 THROUGH-PENETRATION FIRESTOPPING OF FIRE-RATED CONSTRUCTION

- A. Provide systems or devices listed and labeled by a rating agency, and conforming to the construction type, penetrant type, annular space requirements and fire rating involved in each separate instance. The system shall be symmetrical for wall applications. Systems or devices shall be asbestos-free.
 - 1. Additional requirements: Withstand the passage of cold smoke either as an inherent property of the system, or by the use of a separate product included as a part of the rated system or device, and designed to perform this function.

2.22 SMOKE-STOPPING AT SMOKE PARTITIONS

- A. Through-penetration smoke-stopping: Any system complying with the requirements for through-penetration firestopping in fire-rated construction is acceptable, provided that the system includes the specified smoke seal or will provide a smoke seal. The length of time of the fire resistance may be disregarded.

2.70 ACCESSORIES

- A. Fill, void or cavity materials and forming materials: Classified for firestopping use, or included in a rated firestopping assembly, by a rating agency.

PART 3 - EXECUTION

3.02 EXAMINATION

- A. Verification of conditions: Examine areas and conditions under which work is to be performed and identify conditions detrimental to proper or timely completion.
 - 1. Verify barrier penetrations are properly sized and in suitable condition for application of materials.
 - 2. Do not proceed until unsatisfactory conditions have been corrected.

3.05 PREPARATION

- A. Clean surfaces to be in contact with penetration seal materials, of dirt, grease, oil, loose materials, rust, or other substances that may affect proper fitting, adhesion, or the required fire resistance.

3.20 INSTALLATION

- A. Provide firestop devices or assemblies for every opening and penetration in floors or fire-rated construction.
- B. Install penetration seal materials in accordance with printed instructions of the rating agency and in accordance with manufacturer's instruction.
- C. Ensure an effective smoke barrier in each sealed penetration. Install smoke stopping as specified for firestopping.
- D. Protect materials from damage on surfaces subject to traffic.
- E. Where large openings are created in walls or floors to permit installation of pipes, or other items, close unused portions of opening with firestopping material tested for the application.

3.60 FIELD QUALITY CONTROL

- A. Examine penetration seals to ensure proper installation before concealing or enclosing them.
- B. Keep areas of work accessible until inspection and acceptance by applicable authorities.
- C. Before substantial completion, patch and repair firestopping cut or penetrated by other construction work.

3.70 ADJUSTING AND CLEANING

- A. Clean up spills of liquid components.
- B. Neatly cut and trim materials as required.
- C. Remove equipment, materials and debris, leaving area in undamaged, clean condition.

END OF SECTION 220507

SECTION 220509 - PLUMBING EXPANSION SYSTEM

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Precharged bladder-type expansion tank for potable water system.

1.14 RELATED SECTIONS

- A. Piping: Section 221116.
- B. Supports: Section 220529.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Product data: Each type of expansion system or tank, including each relief and air separation device and all accessories.
 - 1. Certification that products comply with NSF/ANSI 61 and NSF/ANSI 372.

1.40 QUALITY ASSURANCE

- A. Potable water system components intended to dispense water for human consumption, including pipe and joining materials, shall comply with the following:
 - 1. A weighted average lead content of not more than 0.25 percent as determined by NSF/ANSI 372.
 - 2. NSF/ANSI 61.
- B. Acceptance product marking: NSF®-61 and NSF®-372 (or NSF®-61-G) or other accepted certifier marks demonstrating third party certification with these requirements.
- C. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified and scheduled products, or comparable products by one of the following:
 - 1. Expansion tanks:
 - a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell and Gossett Domestic Pump Div of ITT
 - d. Taco
 - e. Wessels

2.32 EXPANSION TANK FOR POTABLE WATER

- A. Pressurized bladder type tank, Taco PAX model number scheduled on the drawings, containing impermeable bladder which separates the air cushion from the system water. Operating temperature: 240 degrees F. maximum. Precharge to manufacturer's standard pressure.
- B. Shell: Welded steel, constructed, tested and stamped in accordance with ASME BPV for Unfired Pressure Vessels for a working pressure of 125 psi. Lined with protective coating.
- C. Bladder: Butyl rubber, flexible but not stretchable under working conditions, removable for inspection.
- D. FDA approval: Wetted components FDA-approved materials.
- E. Size and capacity: Shown on the drawings.
- F. Supports: For horizontal or vertical support on concrete equipment foundation, as diagramed on the drawings.

2.36 AUTOMATIC AIR VENT

- A. Float type vent, size and capacity recommended by manufacturer for tank and system.

PART 3 - EXECUTION

3.21 INSTALLING EXPANSION TANKS

- A. Follow manufacturer's instructions and recommendations.
- B. Install piping, air separation apparatus, and vents as diagramed on drawings.
- C. Install supports as shown on drawings.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 220500, provide operating instructions.

END OF SECTION 220509

SECTION 220513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Unless otherwise specified in a particular section or required for a particular application, motors shall conform to the following requirements, whether factory-installed or field-installed.

1.13 PRODUCT FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Motor capacitors: Section 260521, Wiring Connections.

1.14 RELATED WORK SPECIFIED ELSEWHERE

- A. Pumps: Sections 221123.

1.20 REFERENCES

- A. NEMA MG 1: Motors and Generators.
- B. NEMA MG 10: Energy Management Guide for Selection and Use of Polyphase Motors.
- C. NEMA MG 11: Energy Management Guide for Selection and Use of Single-Phase Motors.
- D. UL 508: Industrial Control Equipment.

1.21 DEFINITIONS

- A. Energy efficient motor: Motor meeting the nominal and minimum efficiency levels listed for its horsepower and speed in Table 12-10 of NEMA MG 1.
- B. Nominal efficiency: Efficiency as defined in Table 12-8, Efficiency Levels, in NEMA MG 1, and identified on the motor nameplate.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Product data:
 - 1. Motors and drives not provided with equipment: Show nameplate data and ratings; characteristics; mounting arrangements; size and location of winding termination lugs, conduit entry, and grounding lugs, and coatings.
 - 2. Motor capacitors.
- C. Wiring diagrams required for the proper installation of plumbing equipment.
- D. Submit product data which verifies compliance with ASHRAE 90.1 or provide certified performance ratings by a qualified independent testing agency.
- E. Certifications:

1. Actual motor power factor for each motor, certified test results for each motor proposed for use on this project.
2. Field test showing corrected power factor, if required.

1.40 QUALITY ASSURANCE

- A. Actual motor power factor shall be tested and certified by an independent testing laboratory.
- B. Where power factor is field tested as required in "Power Factor" in Part 2 below, specialist performing tests shall be acceptable to the local authorities having jurisdiction.
- C. UL label and local testing (if required): As specified in Section 220500, Common Work Results for Plumbing.
- D. Plumbing equipment shall meet the energy performance requirements of ASHRAE 90.1.

1.44 REGULATORY REQUIREMENTS

- A. Motors shall conform to the requirements of NEMA MG1 and applicable portions of the National Electric Code (NEC, NFPA 70).

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Motors:
 1. A.O. Smith
 2. Baldor Electric Co.
 3. Marathon
 4. Rockwell
 5. Siemens
 6. Toshiba International
- B. Motor capacitors:
 1. ABB Power Distribution
 2. Commonwealth Sprague
 3. General Electric

2.20 BASIC MOTOR REQUIREMENTS

- A. Capacity: Each motor shall have sufficient capacity and torque to start, accelerate, and operate the machine it drives without exceeding the motor nameplate rating at the speed specified, or at any speed and load which may be obtained by the drive actually furnished.
- B. Starting: Each automatically controlled motor shall be capable of starting as frequently as the control sequence may demand. Motors not automatically controlled shall be capable of making no fewer than 4 starts per hour.
- C. Loads: Belt-connected motors shall be equipped with shafts and bearings designed to withstand both the normal connected loads of the drive furnished, and momentary loads imposed during acceleration.

- D. Ratings: Motors shall be rated for continuous duty at 100 percent of rated capacity, and temperature rise shall be based on ambient temperature of 40 degrees C.
- E. Phase: Unless otherwise indicated, motors one-half horsepower and larger shall be polyphase and motors smaller than one-half horsepower shall be single-phase motors.
- F. Motor construction:
 - 1. Motors for pumps, unless specified otherwise in the equipment section, shall be open drip-proof NEMA design B construction.
 - 2. Motors where indicated or specified, motors mounted outdoors, shall be totally enclosed, fan-cooled (TEFC) extra severe-duty. Motors outdoors inside weather-tight enclosures may be open drip-proof type.
- G. Efficiency: The term "energy efficient" is defined in the article "Definitions" in Part 1 above.
 - 1. Single-phase motors, alternating-current fractional horsepower, rated 1/20 to 1 horsepower, 250 volts or less: NEMA MG 11, types and efficiencies selected for their applications.
 - 2. Polyphase motors, medium alternating-current, squirrel-cage, 1 to 500 horsepower, 600 volts or less: NEMA MG 10, energy-efficient types selected for their application. Nominal full-load efficiencies shall meet or exceed ratings of Table 12-10 of NEMA MG 1.

2.21 SINGLE-PHASE MOTORS

- A. Permanent split-capacitor or split-phase type.
- B. Bearings: Sealed, prelubricated ball-bearing type.

2.22 POLYPHASE MOTORS

- A. NEMA MG1 Design B.
- B. Stator: Copper windings.
- C. Rotor: Squirrel cage.
- D. Bearings: Doubly shielded, prelubricated ball bearings suitable for radial and thrust loading of connected equipment.
- E. Temperature rise shall not exceed insulation rating.
- F. Insulation: Class F.
- G. Motors used with inrush controllers: Match wiring requirements for indicated controller with required motor leads brought to motor terminal box to suit control method.
- H. Horsepower/frame relationship: NEMA Standard for T frame motors.
- I. Motor frame and end shields: Cast iron.
- J. Conduit box: Either steel or aluminum, diagonally split and rotatable in 90-degree increments, with grounding provision.
- K. Finishes:

1. External hardware: Plated to resist corrosion.
2. External paint: Industrial enamel.

- L. Nameplates: Stainless steel or aluminum, and stamped in accordance with NEMA MG1. Nameplate information shall include the nominal efficiency value in accordance with NEMA MG1 and the manufacturer's minimum guaranteed efficiency value.

2.23 ELECTRONICALLY COMMUTATED MOTOR (ECM)

- A. Brushless direct current (DC) variable speed motor supplied with alternating current, with a permanent magnet with near zero rotor losses, permanently-lubricated ball bearings, electronic commutation, designed for synchronous rotation, and at least 70% efficient at all operating speeds.
- B. As a minimum, the motor shall include the following features:
1. Integrated controller / inverter that operates the wound stator and senses rotor position to electronically commutate the stator.
 2. Thermal overload protection.
 3. Built-in soft start and soft speed change ramps.
 4. Inductors to minimize harmonic distortion and line noise.
 5. Designed to overcome reverse rotation without affecting life expectancy.
 6. Include a pulse width modulating (PWM) controller for either manual or DDC controlled motor speed adjustment down to 25% of full speed. The manual PWM controller shall be field adjustable with a standard screwdriver. The remote PWM shall be capable of receiving a 0-10Vdc analog signal from a DDC controller provided by the controls contractor, as indicated or required by other sections of DIV 23 specifications.
 7. Software for motor control as indicated or described in other DIV 22 specifications.

2.26 POWER FACTOR

- A. Power factor for three-phase motors 10 HP and larger and packaged equipment systems totaling 10 HP and larger as noted below shall be not less than 90 percent at full rated load. Test, certify, and submit certified reports for each motor as required in "Submittals" and "Quality Assurance" in Part 1 above.
1. Should the Contractor propose to provide motors with less than 90 percent power factor, provide power-factor-correcting, automatically discharging type motor capacitors. The corrected power factor of the motor-capacitor combination shall be equal to or greater than 90 percent. Submit certified test results.
 2. Motor capacitor: Designed for installation at the load side of motor starters; insulated, impregnated component unit completely enclosed in a grounded steel case with welded and ground seams. Where installed on outdoor equipment, case shall be weatherproof. Provide each unit with a flexible cable for connection to the starter or motor terminals. The capacitor shall be suitable for use in areas with ambient temperatures ranging from minus 10 degrees F to 115 degrees F.
- B. Where motors totaling 10 HP and larger are part of packaged equipment system, the overall power factor for the entire system package shall be no less than 90 percent. Provide capacitors and appurtenances required to accomplish this power factor as part of the packaged equipment, or furnish separately and wire as work of equipment installation. Capacitors shall be stepped, deenergized, or cycled when the unit is deenergized or the load is varied, to maintain 90 percent power factor.

1. Capacitors provided as part of packaged equipment: If the installation of the capacitors voids the UL label, unit shall be tested. Actual power factor shall be factory-tested and certified test results included in submittals.
2. Capacitors provided separately and wired as work of equipment installation: Unit shall then be field tested to verify actual power factor. Submit field test reports.
3. Tests shall be performed by an electrical testing specialist and in accordance with NFPA 70 (NEC) testing brochure.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Mount direct-connected motors securely and in accurate alignment. The drive shall be free from both angular and parallel misalignment when both motor and driven machine are operating at normal temperatures.
- B. Provide each belt-connected motor with a securely mounted adjustable base to permit installation and adjustment of belts.
- C. Mount capacitors shipped separately beside motor connection box as required. Connect in accordance with the requirements of Division 26, Electrical.
 1. Test units at full rated load after the installation of the motor capacitors, and submit reports.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 220500, provide operating instructions.

END OF SECTION 220513

SECTION 220519 - METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Meters and gages for plumbing systems.

1.14 RELATED SECTIONS

- A. Pipe installation and testing: Section 220500.
- B. Valve tags and charts: Section 220523.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Shop drawings: Meter and gage schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gage.
- C. Product data: For each type of meter, gage, device, and fitting specified.
 - 1. Scale range.
 - 2. Ratings.
 - 3. Certification that products comply with NSF/ANSI 61 and NSF/ANSI 372.

1.40 QUALITY ASSURANCE

- A. Potable water system components intended to dispense water for human consumption, including pipe and joining materials, shall comply with the following:
 - 1. A weighted average lead content of not more than 0.25 percent as determined by NSF/ANSI 372.
 - 2. NSF/ANSI 61.
- B. Acceptance product marking: NSF®-61 and NSF®-372 (or NSF®-61-G) or other accepted certifier marks demonstrating third party certification with these requirements.
- C. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Meters and gages:
 - 1. AMETEK; U.S. Gage
 - 2. Ashcroft; Dresser Instrument
 - 3. Miljoco Corporation
 - 4. Taco, Inc.
 - 5. H.O. Trerice Co.

6. Weiss Instruments
7. Weksler; Dresser Instrument

B. Pressure-temperature connections:

1. Miljoco Corporation
2. Peterson Equipment Company
3. Sisco
4. Texas Fairfax Company
5. H.O. Trerice Co.
6. Utilities Materials and Controls, Inc.
7. Weiss Instruments

2.11 THERMOMETERS

- A. General: Industrial, adjustable angle type, accurate to within plus or minus one percent of range span, baked enamel finish, blue reading organic liquid tube, glass or clear acrylic plastic window, dust and moisture tight.

1. Scale size: 9 inches (230 mm).
2. Graduation: To the scale shown on the drawings or of a scale so that the normal working temperature of the system is near the mid-point of the scale.
3. Case: Cast aluminum.

B. Pipe-mounted thermometers: Brass well, separable sockets.

1. Where mounted in insulated piping, thermometers shall have six-inch (150-mm) stem length and sockets with 2.5-inch (64-mm) lagging extension necks. Where mounted in uninsulated piping, they shall have 3.5-inch (89-mm) stem lengths and sockets without lagging extension.
2. Where thermometer wells only are required, provide separable socket with 2.5-inch (64-mm) lagging extension, fitted with attached chain and cap.

2.12 PRESSURE GAGES

- A. Pressure gages shall be accurate to within plus or minus one percent of range span, silver brazed bronze bourdon-tube system, bronze movement, aluminum dial with white background, black graduations and numerals and adjustable pointer, bottom connected.

1. Dial diameter: 6 inches (150 mm).
2. Those installed adjacent to pumps or in pulsating locations shall be provided with pulsating dampeners or snubbers.
3. Case: Cast aluminum or glass filled nylon.

- B. Graduation: To the scale shown on drawings or so pointer is nearly straight up at system normal working pressure.

- C. Gages shall be straight pressure type, except gages on suction side of pumps and inlet side of suction strainers shall be compound type.

D. Gage cock (pressure gage isolation valve):

1. Needle valve: Brass bar stock needle valve, equal to Weksler No. BBV4.

2. Ball valve: Bronze, three-piece body, full port, with Type 316 stainless steel trim, 150 psi (1034 kPa) saturated steam, 600 psi (4137 kPa) non-shock cold water, oil, or gas, equal to Nibco 595-T-66-LF.

2.13 COMBINATION PRESSURE-TEMPERATURE CONNECTIONS

- A. Combination pressure-temperature connections: Equal to UMAC Universal Lancaster Test Plugs, Peterson "Pete's Plug," Sisco, Fairfax P/T Plugs, H.O. Trerice test plugs or Miljoco test plugs. Plugs shall have self-closing valve which will operate at a temperature up to 300 degrees F (149 degrees C). Body and cap shall be brass, and shall receive either a temperature or pressure probe. Provide with a kit including gages and thermometers in a protective case.

PART 3 - EXECUTION

3.21 INSTALLING THERMOMETERS

- A. Pipe line thermometers shall be installed as indicated on the drawings.
- B. Furnish and deliver to Owner at final inspection, three additional pipe line thermometers as above specified, with 6-inch (152-mm) stem lengths, for use in the thermometer wells. Ranges shall be minus 40 to plus 110 degrees F (minus 40 to 43.3 degrees C.); 20 to 120 degrees F (minus 6.7 to 48.9 degrees C.), and 50 to 550 degrees F (10 to 287.8 degrees C).

3.22 INSTALLING PRESSURE GAGES

- A. Each gage connection shall have a gage cock. Connections to pipe lines shall be 0.5 inch (DN 15), with 0.5 inch (DN 15) by 0.25 inch (DN 8) reducer for valve, the assembly of sufficient length to clear insulation.
- B. Where gage cocks only are called for on drawings, provide the 0.5-inch (DN 15) connections to pipe line with reducer and the gage cock.
- C. Provide one compound and one straight pressure gage of appropriate scale to Owner at final inspection.

3.23 INSTALLING COMBINATION PRESSURE-TEMPERATURE CONNECTIONS

- A. Option: Provide combination pressure-temperature connections, complete with kits, where thermometer wells or gage cocks only are called for on the drawings.

END OF SECTION 220519

SECTION 220523 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Valves for various piping systems.
- B. Chainwheel operators.

1.14 RELATED SECTIONS

- A. Piping installation and testing: Section 220500.
- B. Piping systems: Sections 221116, 221316, and 221413.
- C. Automatically operating valves: Section 221119.
- D. Access doors: Section 220503.
- E. Automatic water temperature control valve for domestic hot water: Section 221119.

1.20 REFERENCES

- A. ASME B16.10: Face-to-Face and End-to-End Dimensions of Valves.
- B. ASME B16.34: Valves - Flanged, Threaded, and Welding End.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Product data: For each type of valve. Include body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions.
 - 1. Certification that products comply with NSF/ANSI 61 and NSF/ANSI 372.
- C. Maintenance data: For inclusion in operation and maintenance manual specified in Division 01 and Section 220101. Include manufacturer's instructions for adjusting, servicing, disassembling, and repairing.
- D. Valve charts: Furnish valve charts typed on 8.5 by 11-inch (216 by 279-mm) bond paper, showing locations of all manual and automatic control valves, and flow meters. Include:
 - 1. Number
 - 2. Location
 - 3. Service
 - 4. Function
 - 5. Area served
- E. Valve numbering system shall be approved by the Owner prior to final submittal. Place one copy of approved chart in a plastic envelope and mount on wall where directed. Provide another copy for each of the Operating and Maintenance Manuals.

1.40 QUALITY ASSURANCE

- A. Ferrous valves shall conform to ASME B16.10 and B16.34 for dimension and design criteria.
- B. Copper alloy valves (brass and bronze) shall have no more than 15 percent zinc in the alloy.
- C. Potable water system components intended to dispense water for human consumption, including pipe and joining materials, shall comply with the following:
 - 1. A weighted average lead content of not more than 0.25 percent as determined by NSF/ANSI 372.
 - 2. NSF/ANSI 61.
- D. Acceptance product marking: NSF®-61 and NSF®-372 (or NSF®-61-G) or other accepted certifier marks demonstrating third party certification with these requirements.
- E. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Gate valves: Subject to compliance with requirements, provide the specified NIBCO valve, or comparable product by one of the following:
 - 1. Crane Co.
 - 2. Hammond Valve Co.
 - 3. Lunkenheimer Co.
 - 4. Milwaukee Valve Co.
 - 5. NIBCO
 - 6. Stockham Valve & Fittings
 - 7. Walworth Co.
- B. Ball valves: Subject to compliance with requirements, provide the specified NIBCO valve, or comparable product by one of the following:
 - 1. Apollo Valves
 - 2. Milwaukee Valve Co.
 - 3. NIBCO
 - 4. Stockham Valve & Fittings
 - 5. Victaulic Company of America
 - 6. Walworth Co.
 - 7. Watts Regulator Co.
- C. Check valves: Subject to compliance with requirements, provide the specified NIBCO valve, or comparable product by one of the following:
 - 1. Combination Pump and Valve Co.
 - 2. Mueller Steam Specialty
 - 3. NIBCO
 - 4. Victaulic Company of America

- D. Balancing valves for domestic hot water recirculation: Subject to compliance with requirements, provide the specified Bell & Gossett product or equal.
- E. Backwater valves: Subject to compliance with requirements, provide the specified swing check valves or Zurn valves, or comparable products by one of the following:
 - 1. Ames Company, Inc.
 - 2. Jay R. Smith
 - 3. Jenkins Bros., a corporation
 - 4. Josam Manufacturing Co.
 - 5. Zurn
- F. Hose connections: Subject to compliance with requirements, provide the specified Zurn or NIBCO valves, or comparable products by one of the following:
 - 1. Crane Co.
 - 2. Josam Manufacturing Co.
 - 3. NIBCO
 - 4. Woodford Manufacturing Co.
 - 5. Zurn

2.20 VALVES

- A. Gate valves:
 - 1. Valves NPS 6 (DN 150) through NPS 12 (DN 300); 250 psi WWP, outside screw and yoke, resilient wedge, epoxy coated interior and exterior, iron body construction. NIBCO F-607-RW, flanged.
- B. Ball valves:
 - 1. Valves NPS 0.25 (DN 8) through NPS 2 (DN 50); 600 psi CWP, two-piece silicon bronze alloy body, full port, blowout-proof stem, PTFE seats, stainless-steel ball and stem. Extension handle for use in insulated piping. NIBCO T-685-66-LF, S-685-66-LF, or S-FP-600A-LF, threaded or soldered ends.
 - 2. Valves NPS 2.5 (DN 65) through NPS 4 (DN 100); 400 psi (27.6 Bar) non-shock cold working pressure, two-piece brass body, full port, blowout-proof stem, PTFE seats, forged body and end cap, stainless-steel ball and brass system. NIBCO T-FP-600A-LF or S-FP-600-A-LF, threaded or soldered ends.
- C. Center-guided, spring-loaded silent-action type check valves:
 - 1. Valves NPS 0.5 (DN 15) through NPS 2 (DN 50); 250 psi CWP, silicone bronze body, PTFE disk, stainless-steel stem and spring, NIBCO T-480-Y-LF or S-480-Y-LF, threaded or soldered ends.
- D. Swing check valves:
 - 1. Valves NPS 0.5 (DN 15) through NPS 2 (DN 50); 200 psi CWP, silicone bronze body, PTFE seat, renewable seat and disk, Y pattern, horizontal swing, NIBCO T-413-Y-LF or S-413-Y-LF, threaded or soldered ends.
- E. Balancing valves:

1. NPS 3 (DN 80) and smaller: Calibrated balancing valve equal to Bell & Gossett Circuit Setter Plus.
 - a. Materials: Low-lead brass body (<0.25 percent lead content), stainless-steel ball with carbon filled TFE seat rings.
 - b. Pressure and temperature ports. Differential pressure readout ports across valve seat area.
 - c. Ratings (NPT): Entire assembly 400 psi, 250 degrees F (2758 kPa, 121 degrees C).
 - d. Flow element: Variable orifice flow meter.
 - e. Adjustable pre-set balancing points with memory stop and isolation valve.
 - f. Drain port: 1/4-inch NPT.
 - g. Bi-directional design.
 - h. Bellows type meter gage kit with case, provide one for use on the entire project.

F. Backwater valves:

1. Valves NPS 1.5 (DN 40) and smaller installed above ground: Swing check valve.
2. Valves NPS 2 (DN 50) and larger installed above ground: Zurn Z-1090, flapper type.
3. Valves NPS 2 (DN 50) and larger installed below slab-on-grade: Zurn Z-1095, flapper type with cast-iron floor level cleanout and plug.

2.21 HOSE CONNECTIONS

- A. Hose connections, general: Every hose connection shall be provided with an ASSE 1052 backflow prevention device with two check valves, field testable, with outlet check valve capable of withstanding backpressure up to 125 psi (862 kPa).
1. Where backflow prevention device is not integral with the hydrant or bibb, but added on, provide a hose connection backflow preventer equal to Woodford 37HD2, for freezing and non-freezing conditions, brass and stainless steel.
 - a. Bushing: Threaded, designed to prevent the attachment of a hose if the check valve device should be removed, with O ring.
 - b. Stop collar and stop screw: Stainless-steel, preventing unauthorized removal of the check valve device.
- B. Wall hydrants: Connection suitable for NPS 0.75 (DN 20) hose.
1. Exterior walls: Non-freeze type with integral backflow preventer and automatic drain. Casing and interior parts bronze; face stainless steel. Key-operated. Equal to Zurn Z-1310, length as required for wall thickness.
- C. Hose bibbs: Compression type, with bronze body, stem, and bonnet, chrome-finished where exposed and rough brass where concealed, Class 125 WOG non-shock. Connection suitable for NPS 0.75 (DN 20) hose. Include integral vacuum breaker (if valve is disassembled, hose cannot be attached).
1. Mounted on wall with concealed connection: Angle sillcock, equal to NIBCO Figure No. 63. Provide a removable handle where bibb is accessible to the general public.
 2. Connecting to exposed pipe: Drain valve, equal to NIBCO Figure No. 74.

2.70 CHAINWHEEL OPERATORS

- A. Manufacturers:
 - 1. Babbitt Steam Specialty Co.
 - 2. Roto Hammer Industries, Inc.
- B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
 - 1. Sprocket rim with chain guides: Ductile iron or cast iron, of type and size required for valve. Include zinc coating.
 - 2. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
 - 3. Chain: Hot-dip, galvanized steel of size required to fit sprocket rim.
- C. Chain storage canisters: Non-corrosive canisters for storage of overhead chains, allow for chain loop release in a single downward movement.
 - 1. Canisters: Plastic, safety yellow or orange color, with perforated bottom for drainage and integral release handle, quick-release hooking mechanism and retention lanyard.
 - 2. Attach to each overhead chain loop with 6 feet minimum clearance below canister.
 - 3. Equal to Roto Hammer, Model CHAW "Chain Away."

2.71 VALVE ACCESSORIES

- A. Service box for backwater valve: Fiberglass-reinforced polymer concrete, modular stacking units equal to Hubbell Power Systems; Quazite Enclosures, PC style, manufacturer's standard gray, enclosures and cover rated to support no less than 8,000 lbs. over a 12 by 12-foot area.
 - 1. Size: No less than 17 by 30 inches (432 by 762 mm), depths and number of stacked units required for valve location.
 - 2. Cover: Locking, with two tamperproof stainless-steel bolts.
 - a. Nonskid surface.
 - b. Impressed logo: BWV.
 - c. Pull slot: 1 by 4 inches (25 by 102 mm).
 - 3. Base: Open (no base).
 - 4. Stone filter material: Uniform gradation, AASHTO M 43 size 67 or 7.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Install valves to be readily accessible for operation and maintenance, and with ample clearance for turning handles or operators.
- B. For valves in inaccessible locations, provide access doors as specified in a related section.
- C. Identify valves as specified in Section 220500, Common Work Results for Plumbing.
 - 1. Provide tags for all valves except stop valves on individual fixtures or equipment where their function is obvious, or where the fixture or equipment is immediately adjacent. Numbers shall correspond to those shown on the Valve Chart. Attach tags to valve shaft.

2. Provide ceiling identification tags where valves are above an accessible suspended ceiling. Number shall correspond to tag number.

D. Install chainwheel operators on valves NPS 4 (DN 100) and larger and more than 7 feet (2150 mm) above floor. Extend chains to 6 feet (1850 mm) above finished floor elevation.

3.21 INSTALLING SHUTOFF AND BALANCING VALVES

A. Install shutoff and balancing valves where indicated.

B. Shutoff valves for water piping systems shall be as follows:

1. Sizes NPS 4 (DN 100) and smaller: Ball valves.
2. Sizes NPS 6 (DN 150) and larger: Gate valves.

C. Balancing valves: Locate valve to provide 5 pipe diameters straight inlet and 2 pipe diameters straight outlet.

3.23 INSTALLING CHECK VALVES

A. Provide center-guided, spring-loaded silent-action type check valves in pumped lines, lines subject to pump pressure, and vertical lines.

B. Provide swing-type check valves in gravity lines or horizontal domestic water lines. Provide for backwater valves NPS 1.5 (DN 40) and smaller.

3.24 INSTALLING BACKWATER VALVES

A. Provide backwater valves in plumbing drainage piping where indicated.

B. Service box: Where shown on drawings, install service box with bottom unit resting on stone filter material no less than two inches deep.

1. Follow box manufacturer's instructions, including installation of deep unit at bottom of stacked units.

3.25 INSTALLING HOSE CONNECTIONS

A. Drain valves: Provide interior hose bibbs, NPS 0.75 (DN 20) or size indicated on the drawings, at every low point of a water system, and where indicated.

B. Provide wall hydrants where indicated. In finished areas, locate units so that domestic water connection is concealed inside adjoining partition or furred space.

C. Provide box hydrants where shown on the drawings. Set box hydrants on a flat stone or other solid foundation set on solid subgrade. Brace the side of the hydrant opposite the inlet to solid earth with a flat stone or other solid material. Surround the bottom of the hydrant with crushed stone with a sufficient volume to contain twice the volume of water held in the hydrant barrel. Cover the crushed stone with geotextile and backfill. Provide a 12-inch (305-mm)-square, 4-inch (102-mm)-thick concrete pad around top of hydrant.

END OF SECTION 220523

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Supports for plumbing piping systems and equipment.
- B. Equipment foundations.
- C. Accessories.

1.14 RELATED SECTIONS

- A. Vibration control supports: Section 220548.

1.20 REFERENCES

- A. ASME B31.9: Building Services Piping.
- B. MSS SP-58: Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

1.21 DEFINITIONS

- A. Definitions are from MSS SP-58, "Classification of Piping Systems."
- B. Hot Systems: Maximum operating (service) temperatures 120 degrees F (49 degrees C) and above.
- C. Ambient Systems: Maximum operating temperatures 60 to 119 degrees F (16 to 48 degrees C).
- D. Cold Systems: Maximum operating temperatures 59 degrees F (15 degrees C) and below.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Product data: Provide manufacturer's literature showing compliance with specifications for each type of hanger, and manufactured support, including fasteners and accessory materials.

1.40 QUALITY ASSURANCE

- A. Hangers and supports shall comply with the requirements of:
 - 1. MSS SP-58.
 - 2. ASME B31.9.
- B. Hangers and supports used as components of fire protection systems shall:
 - 1. Comply with NFPA 13.
 - 2. Be listed and labeled by a nationally recognized testing laboratory (NRTL) according to 29 CFR 1910.7.

- C. Qualifications of welders: As specified in Section 220500, Common Work Results for Plumbing.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Hangers

1. Anvil International
2. Carpenter and Paterson, Inc.
3. National Pipe Hanger Corporation
4. PHD Manufacturing, Inc.
5. PHP Systems/Design

B. Support systems

1. Anvil International
2. PHD Manufacturing, Inc.
3. PHP Systems/Design
4. Unistrut

C. Thermal hanger shields

1. Carpenter and Patterson, Inc.
2. Pipe Shields, Inc.
3. Rilco Manufacturing Co., Inc.

2.10 CONCRETE

- A. Concrete shall be no less than 3000-lb (25,000 kPa) strength.
- B. Reinforcement: 6 by 6 inch (150 by 150 mm) welded steel wire fabric, ASTM A 185.

2.11 GROUT

- A. Non-shrink grout: Premixed, consisting of non-metallic aggregate, cement, and water-reducing and plasticizing agents; capable of developing minimum compressive strength of 7,000 psi (48,000 kPa) in 28 days.
1. Sonneborn-Rexnord "SonogROUT"
 2. L&M Construction Chemical Company "Crystex"
 3. US Grout Corporation "Five-Star Grout"

2.20 HANGERS AND SUPPORTS

- A. Types are identified by MSS type numbers in the article Installing "Pipe Hangers and Supports" below.
- B. Materials for hangers and clamps:
1. For copper pipe: Copper plated.
 2. For steel, insulated, and cast-iron pipe: Galvanized in crawl spaces, tunnels, or wet areas; galvanized or factory-painted in other areas.

- C. Insulating-insert materials and protection shields:
1. Insulation-insert material for cold piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa); or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier. Insert thickness shall match adjacent piping insulation thickness.
 2. Insulation-insert material for hot piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa); ASTM C 552, Type II cellular glass with 100-psig (688-kPa); or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength. Insert thickness shall match adjacent piping insulation thickness.
 3. Insert and shield shall cover entire circumference of pipe.
 4. Insert length: Extend 2 inches (50 mm) beyond shield.
- D. Pipe covering protection saddle: Steel, meeting requirements of MSS SP-58 Type 39, with insulating material located in the space between saddle and pipe.
- E. Hanger rod nuts and washers shall be zinc-plated. Hanger rods shall be solid steel, all threaded, and zinc-plated.
- F. Channel: Slotted cold-rolled steel, equal to Power Engineering Company PS 150 S, 12 gage with 0.406- by 3-inch (10 by 76-mm) slots on 4-inch (102-mm) centers.
- G. Wall- and floor-mounted supports: Structural support system equal to Power Engineering Company "Power Strut."
- H. Structural shapes: ASTM A 36.
- I. Steel pipe: ASTM A 53, Grade B, Type E (electric resistance welded), Schedule 40, black and galvanized steel.
- J. Threaded rod: MSS SP-58.

2.22 FASTENERS

- A. Fasteners to concrete: Self-drilling type expansion shields or machine bolt drop-in anchors for drilled holes, equal to ITT Phillips Anchors "Red Head." Fasteners to ceilings shall be vibration and shock resistant. Load applied to fasteners shall not exceed 25 percent of manufacturer's stated load capacity in 3500 psi (24,000 kPa) concrete.
- B. Fasteners to drywall or cavity wall construction: Equal to ITT Phillips Anchors "Red Head" toggle bolts, with hollow wall drive anchors or nylon anchors as required.
- C. Fasteners to wood construction: Lag bolts.
- D. Bolts, nuts, and washers: ASTM A 307, or ASTM A 325 where high strength is required.

PART 3 - EXECUTION

3.20 INSTALLING PIPE HANGERS AND SUPPORTS

- A. Types and locations, refer to MSS SP-58:

Type 1 Clevis hanger:

1. Ambient Systems and Cold Systems of all sizes.

- Type 8 Riser clamp, steel for steel or cast-iron risers and stacks, copper plated for copper risers and stacks.
- Type 10 Copper plated adjustable swivel ring for uninsulated copper piping NPS 0.5 (DN 15) through NPS 4 (DN 100). Use Type 1 for insulated pipe.
- Type 20 Side beam clamp for attaching hanger rods to structural beams. Use proper size clamp to suit beam flange.
- Type 23 C clamp for beams with maximum flange thickness of 0.75 inch (19 mm); for use with single pipes NPS 2 (DN 50) and smaller.
- Type 40 Pipe-covering protection shield of proper size to fit insulation, between hanger and insulation:
1. Size to fit pipe, between hanger and plastic piping.
 2. Include structural insulation insert between protection shield and pipe for piping NPS 2.5 (DN 65) and larger.
 3. Option: Instead of protection shield and structural insert, provide thermal hanger shield.

B. Trapeze piping supports:

1. Field-fabricated from ASTM A 36 steel shapes.
2. Weld steel according to AWS D-1.1.
3. Size threaded rods in accordance with MSS SP-58.
4. Design trapeze support assembly based on supported load plus a 50 percent safety factor.

C. For hangers requiring vibration control, see Section 22 0548.

D. Hanger rod sizes:

PIPE SIZE NPS (DN)	ROD SIZE Inches (mm)
Up to 2 (Up to 50)	0.375 (10)
2.5 to 3.5 (65 to 90)	0.5 (15)
4 and 5 (100 to 125)	0.625 (16)
6 and 8 (150 to 200)	0.75 (20)
8 to 12 (200 to 300)	0.875 (22)

E. Horizontal piping generally shall be supported from above.

1. Attaching to walls: Use two 0.375-inch (9.5-mm) screw-type fasteners for attaching brackets and three 0.5-inch (13-mm) bolt-type fasteners for attaching structural supports.
2. Attaching to bar joists:

- a. Pipes NPS 2.5 (DN 65) and smaller running parallel with joist: Hanger rods welded to top chord of joist at panel points.
 - b. Pipes NPS 2.5 (DN 65) and smaller running perpendicular to joist: Support from every other joist by method of hanging as described above.
 - c. Pipes NPS 3 (DN 80) and larger running parallel with joist: Support from a length of structural channel or angle welded to the top chords of at least two joists at panel points.
 - d. Pipes NPS 3 (DN 80) and larger running perpendicular to joist: Support from every joist by hanger rods welded to top chord of joist at panel points.
 - e. Where large numbers of pipes are grouped together, their individual hangers shall be staggered so as to distribute the load among the available joists.
3. Attaching to steel decks: Attach hanger rods to the hanger tabs on underside of deck, or pass them through the steel deck and secure on top side with nut, locknut and plate washer.
- a. Plate washers: 4 by 8 inches by 0.125 inch thick (100 mm by 200 mm by 6 mm) for 0.375-inch and 0.5-inch (10 mm and 15 mm) rods; 6 by 12 inches by 0.187 inch (150 by 305 by 5 mm) thick for 0.625-inch (16-mm) and larger rods.
 - b. Top of hanger assembly shall be concealed in the concrete fill which will be placed over the deck.
4. Attaching to metal grating:
- a. Piping NPS 2 (DN 50) and smaller running perpendicular with secondary members supporting grating: Attach hanger rods to the secondary members using Type 23 clamps. Hanger rods shall have locknuts.
 - b. Piping NPS 2 (DN 50) and smaller running parallel with secondary members: Attach hanger rods to 2.5 by 2.5 by 0.25-inch (90 by 90 by 8-mm) angles, 12 inches (305 mm) long, that are securely welded to the underside of the grating.
 - c. Piping NPS 2.5 (DN 65) and larger: Support as specified above for bar joist construction.
- F. Hangers and supports shall be spaced as follows:
1. Copper pipe:
 - a. NPS 1.25 (DN 32) and smaller: At least every 6 feet (1.8 m).
 - b. NPS 1.5 and 2 (DN 40 and 50): At least every 8 feet (2.4 m).
 - c. NPS 2.5 (DN 65) and larger: At least every 10 feet (3 m).
 2. Steel pipe:
 - a. NPS 1 (DN 25) and smaller: At least every 6 feet (1.8 m).
 - b. NPS 1.25 and 1.5 (DN 32 and 40): At least every 9 feet (2.7 m).
 - c. NPS 2 to 6 (DN 50 to 150): At least every 10 feet (3 m).
 - d. NPS 8 to 12 (DN 200 to 300): At least every 14 feet (4.3 m).
 - e. NPS 14 (DN 350) and over: At least every 20 feet (6.1 m).
 3. Cast-iron pipe:
 - a. Where joints occur 5 feet (1.5 m) or less apart: At least every 5 feet (1.5 m).
 - b. Where joints occur over 5 feet (1.5 m) apart: At least every 10 feet (3 m).
 4. Cast-iron no-hub pipe: Support within 18 inches (460 mm) of each horizontal joint. Maximum space between hangers: 5 feet (1.5 m).

5. Plastic pipe with solvent cement or thermal-bonded joint:
 - a. NPS 2 (DN 50) and smaller: At least every 3 feet (0.9 m) when line carries liquid; for vent, 6 feet (1.8 m).
 - b. NPS 2.5 (DN 65) and larger: At least every 4 feet (1.2 m) when line carries liquid; for vent, 8 feet (2.4 m).
 - c. Provide protection shield between hanger and plastic pipe at each support point.
 6. Trapeze hangers:
 - a. Spacing shall not exceed the requirements for the smallest pipe in the rack.
 - b. For wood roof trusses, at least every 6 feet (1.8 m).
- G. Cast-iron no-hub pipe:
1. Tighten bands alternately and firmly with a torque wrench to 60 lbs. (265 N) of torque.
 2. Provide piping NPS 6 (DN 150) and larger and all storm piping with buttresses or tie rods at each change in direction.
 3. Brace horizontal piping against horizontal movement; secure closet bends, traps, and similar items against movement in any direction.
 4. Secure vertical piping at the stack base and at each floor.
- I. Provide additional hangers or supports for concentrated loads such as flanges, valves, expansion compensators, fittings, and other specialties.
- J. Provide hangers as required for insulated piping systems. Coordinate selection of hangers and supports with requirements and selected options for insulation continuous through hanger or butted to each side. Provide pipe covering protection shield and structural insulation insert where insulation is continuous through hangers or supports.
- K. Provide pipe risers through floor slabs with riser clamps.
- L. Support PVC vertical risers at each floor and midway between floors.
- M. Support banks of pipes along the wall on a structural support system.
- 3.21 INSTALLING EQUIPMENT FOUNDATIONS AND SUPPORTS
- A. Provide four-inch (100-mm) -high concrete foundations (housekeeping pads), reinforced with welded-wire fabric, for floor-mounted equipment and where indicated. Anchor concrete foundations by dowels inserted into the floor slab.
 - B. Unless otherwise specified, provide concrete foundations, bolts, sleeves, and appurtenances as work of the section where the supported equipment is specified and in accordance with the requirements of Division 03.
 - C. Equipment shall be properly aligned and leveled, and grouted where necessary. Support piping independently of equipment and so as not to cause a strain or thrust.
 - D. Coordinate exact size, configuration and location of equipment, foundations, and supports using approved shop drawings of equipment.

END OF SECTION 220529

SECTION 220548 - VIBRATION CONTROL SUPPORTS FOR PLUMBING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Vibration control supports for plumbing equipment.

1.14 RELATED SECTIONS

- A. Hangers and supports: Section 220529.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Product data: For each type of vibration control support included in the work.
- C. Shop drawings: Custom-fabricated supports.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified Mason Industries product, or comparable product by one of the following:
 - 1. Amber/Booth Company, Inc.
 - 2. Kinetics Noise Control
 - 3. Mason Industries
 - 4. Vibro-Acoustics
 - 5. Vibration Eliminator Company, Inc.
 - 6. Vibration Mountings and Controls, Inc.

2.20 VIBRATION CONTROL SUPPORTS

- A. Provide engineered supports for equipment and locations shown on drawings and specified in Part 3 below. The units shall prevent the transmission of vibration and mechanically transmitted sound to the building structure.
 - 1. Select units in accordance with the weight distribution of the equipment, so as to produce reasonably uniform deflection. Deflections shall be as specified.
 - 2. Units installed on exterior shall be galvanized.
- B. Specification D: Equal to Mason Industries Type 30N hangers, combination spring and minimum 0.3-inch (8-mm) deflection neoprene in series.
 - 1. Neoprene element: Molded with a rod isolation bushing that passes through the hanger box.
 - 2. Spring diameters and hanger box lower hole sizes: Large enough to permit the hanger rod to swing through a 30-degree arc before contacting the edges of the hole.
 - 3. Springs shall have a minimum additional travel to solid equal to 50 percent of rated deflection.

- C. Specification E: Equal to Mason Industries Type PC30N, same as Specification D, except with adjustment to transfer load to spring while holding supported object at fixed elevation. Include spring deflection indicator.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Adjust vibration control supports as recommended by manufacturer to eliminate transmission of vibration to building structure or other systems.
- B. Replace springs that become permanently deformed with new springs.

3.26 PUMP VIBRATION CONTROL

- A. Pumps suspended from structure: Specification E hanger, selected for weight with at least 1 inch (25 mm) static deflection.

END OF SECTION 220548

SECTION 220700 - PLUMBING INSULATION

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Definitions and general requirements applicable to the insulation systems specified in "Related Sections."

1.14 RELATED SECTIONS

- A. Plumbing piping insulation: Section 220719.

1.20 DEFINITIONS

- A. Ceiling space: The space between the ceiling and the floor of an air-conditioned space above.
- B. Roof space: The space between the ceiling and the roof, where building insulation is located at the roof level, or the space between the ceiling and the floor of a non-air conditioned space above.
- C. Attic space: The space between the ceiling and the roof, where building insulation is located at the ceiling level.
- D. Air-conditioned areas or spaces: Areas or spaces where the occupied room temperature is maintained between 65 and 80 degrees F (18.3 and 26.7 degrees C).
- E. Concealed insulation shall include work:
 - 1. Above ceilings.
 - 2. Where furred in and in pipe chases.
- F. Exposed insulation shall include work:
 - 1. Below ceilings in all rooms and areas.
 - 2. In mechanical equipment rooms or mechanical closets.
 - 3. In all rooms without ceilings.
 - 4. In storage rooms.

1.40 QUALITY ASSURANCE

- A. Perform work in strict accordance with the building, fire and safety codes of the state, county or city in which the work is performed.
- B. Insulation, including fittings and butt strips, jackets, facings, and accessories such as adhesives, mastics, cements, tapes and cloth, shall have a fire and smoke hazard rating and label as tested by ASTM E84, NFPA 255, and UL 723, not exceeding Flame Spread 25, Fuel Contributed 50, Smoke Developed 50.
- C. All insulation and accessories shall be free of asbestos.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Deliver insulation and accessory products in manufacturers' wrapping or cartons, identified on the exterior and bearing labels showing conformance to flame and smoke rating requirements.

PART 2 - PRODUCTS

2.10 MATERIALS

- A. Refer to sections listed in "Related Sections."

PART 3 - EXECUTION

Not Used.

END OF SECTION 220700

SECTION 220719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Plumbing piping insulation for the piping systems listed in the schedule at the end of this section.

1.14 RELATED SECTIONS

- A. Sections specifying requirements for LEED rating are specified in Division 01.
- B. Definitions and general insulation requirements: Section 220700.
- C. Painting: Division 09.
- D. Pipe hangers and protection shields: Section 220529.

1.20 REFERENCES

- A. ASTM C 450: Prefabrication and Field Fabrication of Thermal Insulating Fitting Covers for NPS Piping, Vessel Lagging, and Dished Head Segments.
- B. ASTM C 534: Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- C. ASTM C 547: Mineral Fiber Pipe Insulation.
- D. ASTM C 553: Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. LEED submittal:
 - 1. Product data for credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.
- C. Schedule of products: Each type of insulation and accessory, with manufacturer's name and material name and number. Identify locations for use, thickness of material, type of jacket, vapor barrier, and method of application.
- D. Product data: Sufficient to show that the product meets the specified requirements for materials, composition, and performance.
- E. Samples required only upon request.

1.34 QUALITY CONTROL SUBMITTALS

- A. Manufacturer's instructions: Recommended accessory materials and products; installation instructions.

1.40 QUALITY ASSURANCE

- A. Meet requirements specified in Section 220700.
- B. Comply with requirements for LEED certification specified in Division 01.
- C. Installers shall be mechanics skilled in this trade.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Meet requirements specified in Section 220700.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. The listed manufacturers and particular products are intended to set a standard for materials, composition, and performance. Products of other manufacturers may be proposed as permitted by the provisions of Division 01 and the article "Product Options" in Section 220101.
- B. Fiberglass insulation:
 - 1. Johns Manville
 - 2. Knauf Fiber Glass GmbH.
 - 3. Owens-Corning.
- C. Flexible elastomeric insulation:
 - 1. Armacell LLC
 - 2. Rubatex
- D. Coatings, adhesives, and fabrics:
 - 1. Childers.
 - 2. Foster.
 - 3. Manville Building Materials Group.
 - 4. Rock Wool Manufacturing Company

2.10 FIBERGLASS PIPE INSULATION

- A. Fiberglass insulation: Glass fibers bonded with a thermosetting resin.
 - 1. Preformed pipe insulation, ASTM C 547 Type I, with all-service jacket.
 - 2. Flexible sheet insulation, ASTM C 553 Type IV, without facing.
- B. All-service jacket (ASJ): Factory-applied, fire-retardant, vapor-barrier foil/scrim/kraft jacket. All-service jacket with self-sealing lap (ASJ-SSL) is acceptable as Contractor's option.
 - 1. Tape: Matching jacket, pressure-sensitive.
- C. Fittings and valves: Prefabricated and field fabricated, meeting ASTM C 450 requirements for dimensions used in forming insulation to cover valves, elbows, tees, and flanges.

2.11 FLEXIBLE ELASTOMERIC PIPE INSULATION

- A. Flexible elastomeric tube and sheet: Equal to Armacell "AP Armaflex," or "Armaflex 2000", closed-cell, sponge- or expanded-rubber materials, ASTM C 534, Type I (tubular) and Type II (sheet).
- B. Fitting and valve covers: Field fabricated, meeting ASTM C 450 requirements for dimensions used in forming insulation to cover valves, elbows, tees, and flanges.

2.12 ADHESIVES

- A. Joints, fittings, and general application:
 - 1. Fiberglass insulation: Foster "Quick-Tack" 85-60.
 - 2. Flexible elastomeric insulation: Foster "Drion" 85-75.
- B. Lagging adhesive: Polyvinyl acetate adhesive, equal to Foster "Lagfas" 81-42W.

2.13 MASTICS AND COATINGS

- A. Flexible elastomeric insulation: Armacell "WB Armaflex" latex enamel.
- B. Bituminous mastic: Fed. Spec. SS-C-153, Type I.
- C. Insulating and finishing cement: Mineral fiber cement with a hydraulic-setting binder, conforming to ASTM C 449.
- D. Vapor barrier coating:
 - 1. On fiberglass insulation: Foster "Vapor-Fas" 30-65.
 - 2. On flexible elastomeric insulation: Two coats of latex enamel coating.
- E. Finish coating for fiberglass insulation or lagging: Washable, abrasion-resistant, coating equal to Foster "Sealfas" 30-36.

2.14 LAGGING AND REINFORCING TEXTILES

- A. Canvas: Eight ounces/sq. yd. (270 g/sq. m), fire-retardant treated.
- B. Glass cloth and tape: MIL-C-20079. Tape: Type II, Class 3, 4.5 ounce/sq. yd. (150 g/sq. m). Cloth: Type I, Class 1, untreated.

2.15 FASTENERS

- A. Aluminum bands: 0.75 inches (19 mm) wide and 0.020 inches (0.4 mm) thick.
- B. Staples: Outward clinching type, Type 304 or 316 stainless steel.
- C. Pins: Serrated shaft, Type 304 or 316 stainless steel.

2.16 PROTECTIVE PIPE JACKETS

- A. Aluminum: Smooth aluminum 0.016-inch-thick, lined with a bonded moisture barrier, equal to Childers "Aluminum Roll Jacketing."

1. Aluminum straps: Same alloy as jacket.
 2. Elbows: Childers "Univers-El Jacs".
 3. Tees: Childers "Tee-Jacs."
 4. Fitting covers: Manufacturer's factory-fabricated aluminum covers suitable to size of fitting and thickness of insulation.
- B. Polyvinyl chloride (PVC): High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; 20 mils (0.5 mm) thick; roll stock ready for shop or field cutting and forming.
1. Adhesive: As recommended by jacket material manufacturer.
 2. Color: White
 3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. 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.
- C. Canvas: Finished with lagging coating, uniform, smooth, and ready for painting.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Install in accordance with the Minimum Thickness Schedule at the end of this section, as modified by specifications for each location and type.
- B. Insulation conductivity shall meet the 2015 International Energy Conservation Code for listed fluid operating temperature.
- C. Fiberglass insulation: Apply insulation to a neat and smooth finish. Comply with manufacturers' recommendations and installation instructions. Butt joints tightly and apply a brush coat of vapor barrier coating to each lap and joint strip. Seal or fasten laps in jacketing as specified for location, pulling jacketing tight and smooth. Coat all fittings, valves, and flanges with vapor barrier coating and reinforcing mesh before applying fitting covers.
- D. Flexible elastomeric insulation: Apply by slipping seamless sections of tubing over the end of the piping, wherever possible. Use slit tubing only as necessary. Seal joints and slit seams with joint adhesive.
 1. Fittings and valves: Field fabricated from insulation same thickness as on the piping. Use manufacturer's miter tubes and boxes and templates.
- E. Tape and seal with vapor barrier coating to all terminations of insulation.
- F. Staple, tape, or seal plastic pipe fitting covers by methods recommended by manufacturer.
- G. Coordination with pipe hangers and supports:
 1. Insulation shall be continuous through hangers for all piping systems. Install pipe covering protection shields with thickness of structural insulation inserts equal, under load, to that of adjoining insulation. Shields and saddle supports are specified in Section 220529, Hangers and Supports for Plumbing Piping and Equipment.

3.21 INSTALLING INSULATION AT PENETRATIONS

- A. Where insulated piping systems pass through sleeves or openings in partitions and floors, the insulation shall be continuous through the sleeves and openings. See Firestopping specifications, for coordinating insulation and fire protection sealing.

3.22 INSTALLING CANVAS JACKET

- A. Locations:
 - 1. All pipe insulation in mechanical rooms and mechanical closets on exposed piping as defined in Section 220700, Plumbing Insulation.
 - 2. Canvas jacket is not required where aluminum jacket is required.

3.23 INSTALLING ALUMINUM JACKET

- A. Locations: All insulated pipe exposed in finished areas within 8 feet (2440 mm) of the finished floor, and as specified for weather protection.
- B. Secure jacket with aluminum bands on 12-inch (305-mm) centers and at circumferential joints.
- C. Place longitudinal joints to face a wall and overhead joints to face the ceiling.

3.24 INSTALLING PVC JACKET

- A. Locations: All insulated piping in crawl spaces, and as specified for weather protection.
- B. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of pipes. 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.
 - 2. Seams and joints shall completely prevent the entrance of water.

3.26 INSTALLING PLUMBING PIPING INSULATION

- A. Insulation: Fiberglass, thickness in accordance with Minimum Thickness Schedule.
- B. Fittings, valves, and flanges: Cover with prefabricated fitting covers. Coat all fittings, valves, and flanges with vapor barrier coating and reinforcing mesh before applying fitting covers.
- C. Seal or finish to maintain vapor barrier on the following systems:
 - 1. Aboveground domestic cold water
 - 2. Air-conditioning unit condensate drains,
 - 3. Floor drain bodies and piping receiving air-conditioning unit condensate
 - 4. Vertical and horizontal storm water piping and roof drain sump
- D. Seal or staple ASJ as contractor's option: Aboveground tempered, recirculating and domestic hot water.

- E. Exception: On vertical storm-water piping built within walls or inaccessible chases, insulate only the first 5 feet above the point where the pipe turns to go underground. Insulate all storm-water piping connecting to drains receiving air-conditioning condensate.
- F. Roof drain pans and above ground floor drain pans that receive air-conditioning condensate: Fiberglass insulation, 1 inch thick. Provide vapor barrier. Finish with two coats of vapor-barrier coating with glass cloth embedded in final coat.

3.27 INSTALLING EXTERIOR PIPING INSULATION

- A. Locations: Piping systems exterior of building heated space.
 - 1. Air-conditioning condensate except where discharging on roof or ground.
 - 2. Domestic water
 - 3. Floor drains
 - 4. Sanitary piping
 - a. Where required, install electric heat cable before applying insulation.
- B. Insulation: As specified for the same system interior, minimum thickness 2 inches (50 mm), or 0.5 inches (13 mm) thicker than scheduled for interior insulation on similar system, whichever is greater.
- C. Start insulation 30 inches (760 mm) below grade, 30 inches (760 mm) below roof or 30 inches (760 mm) inside exterior wall. Secure insulation with aluminum bands on 12-inch (305-mm) centers.
- D. Where insulated piping is exposed to weather, apply one of the following protective jackets:
 - 1. Over fiberglass insulation:
 - a. PVC jacket.
 - 2. Over flexible elastomeric insulation: Fully adhere a layer of glass cloth to the insulation surface, with adhesive specified for elastomeric system. Apply two coats of latex enamel finish.

3.90 SCHEDULES

- A. Minimum Thickness Schedule: Thicknesses scheduled are for aboveground, interior piping. See "Installing Exterior Piping Insulation" for additional thicknesses required.

(See Schedule, next page)

MINIMUM THICKNESS SCHEDULE							
PIPE SIZES (NPS)							
Piping System Types	Fluid Temp. Range (Degrees F)	Equipment Connections Up to 1-1/4	1-1/2 & less	2	3 to 4	5 & 6	8 and larger
Domestic cold water	40-180		1.0**	1.0**	1.0	1.0	1.0
Domestic hot and recirculating	100-140	1.0	1.5	1.5	1.5	--	--
Storm water	---	--	1.0**	1.0**	1.0**	1.0**	1.0**
Roof drains	---	--	1.0	1.0	1.0	1.0	1.0
Air-conditioning condensate	---	--	1.0**	1.0**	1.0**	1.0**	1.0**
Floor drains (1)	---	--	--	1.0	1.0	1.0	1.0
Sanitary piping (1)	---	--	--	1.0	1.0	1.0	1.0

** Contractors Option within partitions only: 0.5-inch flexible elastomeric insulation.

(1) - Above ground, receiving air-conditioning condensate.

END OF SECTION 220719

SECTION 220800 - COMMISSIONING OF PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 and other applicable Sections, apply to Work of this Section. Failure to meet Cx requirements and failure to correct noncompliance and/or deficiencies subjects the Contractor to withholding of payments and completion. See General Conditions.
- B. Section 014000 "Quality Requirements" Section- the Cx Plan shall apply to Work of this Section and must be properly coordinated. The Contractor shall satisfy all requirements of this Section and of the Cx Plan. In the event of conflict, the requirement that is considered most stringent by the Owner shall be considered in force.
- C. Section 220500 "Plumbing General Provisions" shall be made an integral part of this Section.
- D. Individual Division 22 Sections: Individual Sections which stipulate installation, startup, warranty and training requirements for the system or device specified in the Section.
- E. Commissioning Plan (Cx Plan) – Stipulates the relationships between the parties involved with the Cx process. Defines the milestones in completion incorporating the Cx process.
- F. Division 01 "Submittal Procedures": Stipulates additional copies of submittals to be submitted and refers to other sections for additional submittal requirements related to Cx.
- G. Division 01 "Closeout Procedures: Provides general requirements and specifications for O&M Documentation for Work across all Divisions.
- H. Section 230800 – Commissioning of Mechanical Systems: Section stipulates detailed requirements of Cx for all applicable plumbing systems.
- I. Section 260800 – Commissioning of Electrical Systems: Section stipulates detailed requirements of Cx for all applicable electrical systems.

1.2 REFERENCE STANDARDS

- A. ASHRAE Guideline 1.1-2007, The HVAC Commissioning Process, American Society of Heating Refrigeration, and Air Conditioning Engineers, Atlanta, GA. www.ashrae.org
- B. ASHRAE Guideline 4-2008, Preparation of Operating and Maintenance Documentation for Building Systems, American Society of Heating Refrigeration, and Air Conditioning Engineers, Atlanta, GA. www.ashrae.org
- C. National Environmental Balancing Bureau, 'Procedural Standards for Building Systems Commissioning'.

1.3 SUMMARY

- A. Commissioning (Cx) is a systematic process of ensuring that building systems perform interactively according to the design intent and the owner's operational needs. For purposes of this project, the Cx process occurs during the construction, acceptance, and early occupancy phases. The objectives of this Cx process are as follows:
1. Ensure that installed systems are operable and maintainable.
 2. Maintain a high level of quality assurance.
 3. Test and verify the applicable heating, ventilating, and air conditioning (HVAC) and automatic temperature control (ATC) systems to ensure they are interacting and performing optimally.
 4. Ensure proper documentation of the Cx process including meeting minutes, equipment start-ups, pre-functional checklists (PFC), and functional performance tests (FPTs). (Responsible party for completing specific documentation is outlined in Cx responsibilities section.)
 5. Identify, track, record, and report all system and equipment deficiencies in the Cx Issues Log.
 6. Provide technical expertise for the correction of deficiencies.
 7. Ensure O&M documentation delivered to Owner is complete.
 8. Document warranty start and end dates.
 9. Meet or exceed all the Cx requirements for "Fundamental Commissioning" and "Enhanced Commissioning" as outlined in EA Prerequisite 1 and EA Credit 3, LEED New Construction Version 2.2.

1.4 DEFINITIONS AND ABBREVIATIONS

- A. Refer to the Cx Plan for additional definitions and abbreviations related to the Cx process.
- B. Commissioning Agent (CxA): Independent firm retained by the Owner to conduct the Cx Program. The CxA shall work with the various subcontractors, the Architect, and the Engineer-of-Record (EOR) to direct and oversee the Cx process and perform Functional Performance Testing (FPT).
- C. Commissioning Milestones: Cx Milestones are scheduled events that mark defining progress completion points in the execution of the Cx process. Cx Milestones include specific Meetings and Training Events as defined in the Cx Plan. Regularly scheduled construction progress or working meetings are not considered Cx Milestones.
- D. Commissioning Plan (Cx Plan): The Cx Plan outlines the entire Cx process in detail. The Cx Plan is part of the Contract Documents and outlines many of responsibilities, procedures and tasks throughout the Cx process from Design through Occupancy. It also indicates the details of the FPT that the Construction Manager (CM) and associated Contractors must participate in. The Cx Plan provides a detailed description of the work required by the CxA. Further, it is imperative that the CM and all associated Contractors read and understand the implications and procedures outlined in the Cx Plan prior to submitting their bid for the Work.
- E. Commissioning Program: This is a general reference to the entire Cx process and associated documents. The Cx process refers to all work
- F. Commissioning Team: The group of individuals who will collaborate to ensure the facility is fully and completely commissioned. The Cx Team will generally include a core group of individuals involved with all systems. This core group shall include the CxA, the GC, the Owner, and Owner's Construction Manager (if applicable). On any given system, the team will also include the member of the contractor(s) responsible for the systems or equipment.

- G. Functional Performance Test(ing) (FPT): The detailed and thorough testing of the building systems and their interactions with the building components and other building systems to ensure they are operating in accordance with the final design intent. Testing is performed in various modes of operation and conditions. Both component performance and environmental design objectives will be monitored during this testing. Functional Performance Tests (FPTs) are tests developed by the CxA with input from appropriate Cx Team members that, when passed, indicate Functional Completion of the system or equipment.

1.5 COMMISSIONING TEAM

- A. The CxA shall designate a Commissioning Team (Cx Team) consisting of all members needed to execute the approved Cx Program. Definitions of these Parties are provided in the Cx Plan. Minimum Cx Team participation shall include:
1. CxA
 2. Owner's Representatives (Owner)
 3. Controls Contractor (CC)
 4. Mechanical Contractor (MC)
 5. Plumbing Contractor (MC)
 6. Testing, Adjusting, and Balancing (TAB) Contractor
 7. Electrical Contractor (EC)
 8. Architect

PART 2. PRODUCTS (NOT USED)

PART 3. EXECUTION

3.1 COMMISSIONED SYSTEMS

- A. The following mechanical systems, equipment and components will be commissioned by Facility Dynamics, the CxA under this project. Where applicable, sampling may be used to test the equipment listed below. Refer to the Cx Plan for sampling rates. This would allow for a representative portion of the equipment to be tested and not every unit. All general references to the equipment in this document refer only to equipment that shall be commissioned.
1. Domestic Water Heaters
 2. Domestic Water Pumps
 3. Thermostatic Mixing Valves
 4. Sensor Operated Plumbing Fixtures

3.2 COMMISSIONING MILESTONES AND PARTICIPANTS

- A. The following are the Cx Milestones (Cx-specific meetings and training events) required under this Contract. Complete descriptions, including Schedule and Attendees, are provided in the Cx Plan. They are provided here as a summary for the Contractor and associated Contractors. These Milestones are in addition to regular construction progress meetings and FPTs that are scheduled as systems and equipment are ready for testing.
1. Construction Phase Commissioning Scoping Meeting. Required Attendees include the CxA (lead), Construction Manager (CM), and Mechanical, Electrical, and Controls Contractors. Other required attendees include Owner Representatives, EOR, and Architect.

2. Commissioning Progress Meetings. Required Attendees include the CxA (lead), CM, and Mechanical, Electrical, and Controls Contractors. Other required attendees include Owner Representative, and Tab Contractor.
3. Maintenance Orientation and Inspection Meeting – 1. Required Attendees include the Mechanical Contractor (lead), CxA (assist), Electrical and Controls Contractors. Other required attendees include EOR, CM, Owner Representatives, and Architect.
4. Maintenance Orientation and Inspection Meeting – 2. Required Attendees include the Mechanical Contractor (lead), CxA (assist), Electrical and Controls Contractors. Other required attendees include EOR, CM, Owner Representatives, and Architect.
5. Owners Training of Cx Systems. Required Attendees include the CxA (lead), Construction Manager (CM), Owner Representatives and Operators. Applicable contractors and EOR may also be required.
6. Final Cx Meeting. Required Attendees include the CxA (lead), CM, and all Contractors involved in the Cx Team. Other required attendees include Owner Representatives, EOR, and Architect.

3.3 COMMISSIONING DOCUMENTATION

- A. The Design Phase Cx Plan is written by the CxA and included in the Contract Documents. The Plan shall be updated in accordance with the Cx Plan Progression Section in the Cx Plan.
- B. The Cx Issues Log shall be maintained by the CxA. It is used to track Cx-related issues or deficiencies found throughout the project. A sample Issues Log is included in the appendix of the Cx Plan. Refer to the Cx Documentation section in the Cx Plan for more information.
- C. CxA shall require Submittals relating to key systems or equipment from the Contractor as specified in the Cx Plan to ensure Owner's Requirements are met and facilitate the preparation of FPTs. Review is for Cx facilitation only and does not replace the Submittal Review of the Architect or EOR.
- D. The TAB Contractor is responsible for submitting a TAB Plan, in accordance with the Cx Plan, prior to beginning TAB of the building.
- E. The Controls Contractor (CC) is responsible for submitting a Controls Checkout Plan, in accordance with the Cx Plan, prior to beginning TAB of the building.
- F. The CxA will provide the Contractor with initial "generic" Pre-Functional Checklists. The Contractor is responsible for completing the Pre-Functional Checklists and Start-up Reports in accordance with the Cx Plan and other Contract Documents.
- G. The Contractor shall provide Trending Reports in tabular and graphical formats in accordance with the Cx Plan and Trending Request Forms prior to the start of the FPTs.
- H. The FPT procedures shall be developed by the CxA and provided to the Contractor for review prior to the start of the FPTs. Refer to the Cx Plan for additional information.
- I. The Contractor shall develop a Training Plan in accordance with the Cx Plan and other Contract Documents.
- J. The Contractor shall develop the Operation and Maintenance Manuals in accordance with the Cx Plan and other Contract Documents.

3.4 SEQUENCING AND SCHEDULING COMMISSIONING TASKS

- A. Contractor shall incorporate the Cx Program into the project schedule and timelines.
- B. Cx tasks to be separately indicated in the project schedule include but are not limited to:
 - 1. Start-Up: Indicate time required to properly perform Start-Up of each system and complete Start-Up Documentation.
 - 2. TAB: Include sufficient time for TAB work to be completed and checked.
 - 3. FPT: Indicate time required for FPTs, itemized as applicable for each system/area. Coordinate duration for the tasks with the CxA.

3.5 COMMISSIONING PROTOCOLS

- A. Coordination responsibilities and management protocols relative to Cx are initially defined in the Cx Plan and will be refined and documented at the Construction Phase Cx Scoping Coordination Meeting and also by scheduled updates to the Cx Plan. Contractor shall have input in the protocols and all Parties will commit to scheduling obligations. The CxA will record and distribute.

3.6 COMMISSIONING RESPONSIBILITIES

A. General

- 1. All parties involved in the design and construction of the facility bear responsibility in the Cx Program. The Cx Program does not fundamentally change the responsibilities of the team members from conventional projects carried out without a formal Cx Program. The Cx Program supplements and formalizes the responsibilities of all parties.
- 2. The role of the CxA is to oversee the Cx Program and to assist all other parties in achieving the goals of the project. Refer to the Cx Plan for further detail.
- 3. The Contractor (and associated Sub-Contractors) retains all responsibility for the installations. CxA inspections and tests will determine the adequacy and completeness of the installations to assist the Contractor in providing a sound installation. CxA testing does not alleviate the Contractor's responsibility for ensuring the systems are complete and functional throughout the Warranty Period.
- 4. Detailed responsibilities for the Mechanical Contractor and associated Sub-Contractors are indicated below. Refer to the Cx Plan for detailed responsibilities for other Contractors and Cx Team members. These responsibilities relate solely to the Cx Program and do not encompass all aspects of the project.
- 5. Some scopes or tasks indicated in the following list of responsibilities are further detailed in other subsections of the Cx Plan, including descriptions of meetings, training events, and required reports.

B. Mechanical Contractor's (MC) Responsibilities

- 1. Attend Cx meetings, FPTs, and Training as outlined in the specifications, the Cx Plan, and as summarized in this subsection.
- 2. Include requirements for submittal data, including O&M data and training materials in each purchase order or sub-contract written. Provide submittals in electronic format originating from the manufacturer to ensure the highest resolution/quality.
- 3. Ensure cooperation of other Sub-Contractors as necessary.
- 4. Ensure cooperation and participation of specialty Sub-Contractors as necessary.
- 5. Ensure participation of major equipment manufacturers and their representatives as needed. Note all commissioned equipment that is standalone or provided with factory mounted controls will require the support of the start-up technicians during Cx FPTs.

6. Gather O&M data on all equipment, assemble electronically. Provide electronic manuals in accordance to Sections 01 77 00 Closeout Procedures, 23 05 00 Common Work Results for HVAC, and other related Sections. Submit to CM after the equipment has been placed. O&M data shall be forwarded to CxA for use in preparing FPT's.
7. Attend Cx meetings and training events as outlined in the Cx Plan and other Contract documents.
8. Participate in and schedule vendors and Sub-Contractors to participate in the training sessions outlined in this plan and Contract Documents.
9. Conduct Maintenance Orientation and Inspection Meetings at the Equipment Placement and Distribution Completion stages. Update drawings electronically to the record condition to date, and review with the CxA prior to each Meeting.
10. Prepare necessary preliminary schedule for maintenance orientation and inspection meetings, O&M manual submission, training sessions, duct system testing, flushing and cleaning, equipment start-ups, TAB start and job completion for use by the CxA. Update schedule as appropriate throughout the construction period.
11. Notify the CxA of the time for start of the TAB work. Attend the TAB Concurrence Meeting for review and acceptance of proposed TAB procedures.
12. Attend and participate in all Cx FPT's per the Cx Plan.
13. Provide all training in accordance with Contract Documents. Video tape training if required in the project specifications.
14. The appropriate Contractor Representative or Manufacturer's Representative (in the case of factory testing and startup) shall provide written certification that the following work has been completed in accordance with the plans and specifications and that they are functioning as designed. Where the Work has been subcontracted, the Sub-Contractor shall be responsible for the initial certification with the primary Contractor Representative re-certifying that he has inspected the Work and that it has been completed and functioning as designed. This certification must be submitted to the CxA prior to the final verification. Certifications are required for the following systems:
 - a. Domestic Water System
 - b. All Division 22 equipment
15. Assist the CxA in documentation and verification of equipment and system performance, including but not limited to FPTs. Schedule the Sub-Contractors (including but not limited to TAB, CC) to assist during FPTs as required.
16. Provide all tools and equipment necessary to perform FPTs, including those necessary for simulation of false loading as required by the CxA.
17. Turn over set of record mark-ups to the Mechanical and Plumbing EORs for final incorporation into Record Documents.

C. Controls Contractor's (CC) Responsibilities

1. All requirements of MC and EC shall apply as applicable to the CC, including requirements for Submittals, O&M manuals and data, and training data and materials.
2. The CC is a crucial member of the Cx Team and will be required to be available for most FPTs, as well as verify, demonstrate and train the Operators on the overall system operation and sequence of operation. The CM shall ensure that the CC is made fully aware of his/her role and importance to a successful Cx effort.
3. Attend Cx Milestone meetings and training events as outlined in the Cx Plan and also as specified in appropriate control systems specification Section.
4. Attend and participate in all Cx FPT's per the Plan and spec. sections. The CC shall be required to demonstrate all control and system sequences of operation to the CxA and other members of the Cx Team.
5. Provide and participate all training in accordance with Contract Documents.

D. Testing, Adjusting, and Balancing Contractor's (TAB) Responsibilities

1. Perform all Work as specified in construction specifications.
2. Submit a TAB work plan as a formal Cx submittal for Cx review and approval. If this is already being submitted to the EOR then a separate Cx submittal is not required.
3. Attend initial Cx Scoping Meeting scheduled by the CxA.
4. At the completion of the TAB work, notify the MC, and demonstrate to the CxA the performance of the equipment covered by the TAB sub-contract.
5. Repeat any measurement contained in the TAB report where required by the CxA for verification or diagnostic purposes.
6. Provide and participate in all training in accordance with Contract Documents.

E. Equipment Suppliers and Miscellaneous Specialty Contractors

1. Attend Meetings as outlined in the Cx Plan.
2. Participate in training sessions as outlined in the Cx Plan and other Contract documents.
3. Demonstrate performance of equipment as applicable.

3.7 CONTRACTOR NOTIFICATIONS

- A. Contractors shall completely install, thoroughly inspect, startup, test, adjust, and balance systems and equipment. All activities shall be documented on Start-Up Documentation forms developed by the Contractor and reviewed by the CxA. The Contractor shall notify Owner and CxA in writing that systems are complete and ready for verification and FPT. CxA shall then coordinate and schedule the FPT and notify all Cx Team members.
- B. Contractor shall notify CxA at least 14 days in advance of any tests, startups, or training. CxA shall witness selected tests and startups. Minimum requirements for Start-up Documentation are provided in Part 2 of this section.

3.8 START-UP AND PRE-FUNCTIONAL TESTING PROCEDURES

- A. Refer to Division 22 and other applicable specification sections for specific start-up procedures for HVAC equipment. Unless otherwise noted, these procedures are the direct responsibility of the Contractor as a basic element of validating that the installation is correct. The manufacturer start-up forms shall be completed and submitted to the CM and CxA for review in accordance with the Cx Plan.
- B. The CxA shall provide pre-functional checklists to the Contractor electronically. The Contractor is responsible for completing these forms and submitting the completed forms to the CM and CxA for review in accordance with the Cx Plan.
- C. Functional Performance Tests provide the final metric for CxA approval and are provided by the CxA in the Cx Plan. Contractor shall consult the most current version of the Cx Plan to determine applicable FPTs that will be used for system acceptance.

3.9 GENERIC FUNCTIONAL PERFORMANCE TESTS (FPT)

- A. General

1. Contractor shall refer to the Cx Plan for detailed information concerning the scheduling, prerequisites, and generic system/equipment testing requirements for the functional performance tests.

END OF SECTION 220800

SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Domestic cold water.
- B. Domestic hot water.
- C. Recirculated hot water.
- D. Tempered water.

1.14 RELATED SECTIONS

- A. Piping materials and methods: Section 220500.
- B. Trenching: Section 220501.

1.20 DEFINITIONS

- A. Domestic water system: Potable water system for general human use, including hot and cold water supply and return.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Product data: Each type of pipe and fitting included in the project.
 - 1. Certification that products comply with NSF/ANSI 61 and NSF/ANSI 372.
- C. Submit proposed method for providing electrical continuity at pipe joints in water service line.
- D. Submit proposed means for anchoring pipes at water service entrance.
- E. Certifications: Disinfection test report

1.40 QUALITY ASSURANCE

- A. Potable water system components intended to dispense water for human consumption, including pipe and joining materials, shall comply with the following:
 - 1. A weighted average lead content of not more than 0.25 percent as determined by NSF/ANSI 372.
 - 2. NSF/ANSI 61.
- B. Acceptance product marking: NSF®-61 and NSF®-372 (or NSF®-61-G) or other accepted certifier marks demonstrating third party certification with these requirements.
- C. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.

- D. Pipe shall be certified by the manufacturer to meet referenced standards and shall bear a label directly on the pipe, indicating compliance.

PART 2 - PRODUCTS

2.01 ACCEPTABLE SUPPLIERS

- A. Disinfection of domestic water system:
 - 1. ARC Water Treatment Company, Inc.
 - 2. Ecolab
 - 3. Water Chemical Services, Inc.
 - 4. Olin Water Services

2.11 ABOVEGROUND PIPE AND FITTINGS

- A. Pipe: Copper tubing, ASTM B 88, Type L, hard drawn, plain end, or roll grooved; cut grooved not permitted.
- B. Fittings:
 - 1. For plain-end copper pipe: Solder joint, cast brass, ASME B16.18, or wrought copper, ASME B16.22.
 - 2. For grooved pipe, copper:
 - a. Couplings, gasket, and fittings capable of withstanding a constant temperature of 230 degrees F (110 degrees C), and 175 psi (1207 kPa) working pressure.
 - b. Reducing couplings not permitted; use reducing fittings at changes in pipe size.
 - c. Gaskets: EPDM.
 - d. Copper: Equal to Victaulic Style 606, designed to fit copper tube, coupling housing fastened with two bolts and nuts.
- C. Flanges for copper pipe: Bronze, solder type, ASME B16.24, Class 150.
- D. Unions for copper pipe: Cast bronze or wrought copper with solder ends, ASME B16.18 or B16.22.
- E. Dielectric nipples shall comply with Section 221119.
- F. Elbows in piping NPS 4 (DN 100) and larger shall be long radius type.

2.13 UNDERGROUND PIPE AND FITTINGS

- A. Pipe:
 - 1. Iron pipe: Class 54, cement mortar lined ductile iron, AWWA C-151.
 - a. Cement lining, AWWA C-104.
 - b. Mechanical or push-on joints, AWWA C-111.
 - 2. Copper tubing, ASTM B 88, Type K, hard drawn, plain end.
- B. Fittings:

1. Iron: AWWA C-110, ductile iron, Class 350.
2. Copper: Solder joint, cast brass, ASME B16.18, or wrought copper, ASME B16.22.

C. Abutments: Concrete, not less than three pipe diameters wide and two pipe diameters high.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Install domestic water piping as shown on the drawings and in accordance with the provisions of Section 220500, Common Work Results for Plumbing.
- B. Install aboveground piping in accordance with the Schedule of Pipe Systems, Sizes, and Materials at the end of this section.
- C. Underground pipe:
 1. NPS 3 (DN 80) and larger: Ductile iron.
 2. NPS 2.5 (DN 65) and smaller: Copper Type K.
- D. Provide hose connections with vacuum breakers at low points of domestic water system for drainage.
- E. Provide dielectric nipples between ferrous and copper piping.

3.22 EXTERIOR UNDERGROUND PIPING

- A. Pipe: Install as indicated on the drawings.
- B. Electrical continuity at pipe joints in water service line shall be provided by conductivity strips, wedges, or other approved methods.
- C. Use suitable tools and appliances for the safe and convenient handling and laying of the pipe. Prevent injury to the pipe coating. Examine each section of pipe for defects, and do not lay sections found to be defective. If any defective piece should be discovered after having been laid, remove it and replace with a sound one at no change to the contract sum.
- D. Install abutments at each change in direction of iron pipe, resting on and transmitting thrust to undisturbed earth.
- E. Anchor water service for cast iron pipes at point of entrance into building by means of clamps or special fittings, as approved.
- F. At the point of water service entrance, provide a shutoff valve as indicated.

3.75 CLEANING AND TESTING PIPING SYSTEMS

- A. When a domestic water loop is completed, and before strainer baskets are installed, pressure test at the pressure shown in Piping Test Table in Section 220500, and thoroughly flush. Water piping connections for flushing shall be same size as piping being flushed or one size smaller. When a major section of the building is completed, repeat the same procedure, except that water pipe connections for flushing shall be limited to NPS 1.5 (DN 40). Then install strainer baskets and conduct a preliminary operation test.

3.76 DISINFECTION OF DOMESTIC WATER SYSTEM

- A. Disinfect the entire domestic water system installed under this contract, cold, hot and return piping, before using. Unless prescribed otherwise by the county or state health department, the method of disinfecting shall be as follows:
1. Through a NPS 0.75 (DN 20) hose connection in the main entering the building, pump in sufficient sodium hypochlorite to produce a free available chlorine residual of not less than 200 ppm. Provide plumbing connections and power for service organization for pumping chlorine into the system.
 2. Proceed upstream from the point of chlorine application, opening each faucet and tap until chlorine is detected. Close each faucet and tap when chlorine is evident.
 3. When chlorinated water has been brought to every faucet and tap with a minimum concentration of 200 ppm chlorine, retain this water in the system for at least three hours, but no more than 3.5 hours.
 4. At the end of the retention period, no less than 100 ppm of chlorine shall be present at the extreme end of the system.
 5. Open all faucets and taps and flush all lines until the chlorine residual in the water is less than one ppm.
 6. Obtain a representative water sample from the system for analysis by a recognized bacteriological laboratory.
 7. If the sample tested for coliform organisms is negative, the service organization shall submit a letter and laboratory report to the Contractor, certifying successful completion of the sterilization. Submit report.
 8. If any samples tested indicate the presence of coliform organisms, the entire sterilization procedure shall be repeated.
 9. Close main sprinkler valves or branch sprinkler valves prior to disinfection of system. Open valves when disinfection is complete.

3.90 SCHEDULE OF PIPE SYSTEMS, SIZES AND MATERIALS

Pipe Types Listed Below			
System	1	2	3
Cold water	X	X	X
Hot water	X	X	X
Hot water Return	X	X	X
Tempered water	X	X	X

<u>Pipe Desig.</u>	<u>Description</u>
1	NPS 4 (DN 100) and smaller; copper Type L.
2	NPS 5 (DN 125) and larger; copper Type L.
3	NPS 3 (DN 80) to NPS 6 (DN 150); copper, rolled grooved.

END OF SECTION 221116

SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Specialties for plumbing piping systems.

1.14 RELATED SECTIONS

- A. Piping: Section 221116.
- B. Access doors: Section 220503.
- C. Expansion tanks: Section 220509.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Product data: For each specialty included in the work. Include rated capacities of selected equipment and manufacturer's installation instructions where applicable. Indicate materials, finishes, dimensions, required clearances, methods of assembly of components; and piping and wiring connections.
- C. Backflow preventer for fire suppression connection: Provide a copy of the approved product performance data to the subcontractor doing sprinkler system calculations for the project.

1.40 QUALITY ASSURANCE

- A. Potable water system components intended to dispense water for human consumption, including pipe and joining materials, shall comply with the following:
 - 1. A weighted average lead content of not more than 0.25 percent as determined by NSF/ANSI 372.
 - 2. NSF/ANSI 61.
- B. Acceptance product marking: NSF®-61 and NSF®-372 (or NSF®-61-G) or other accepted certifier marks demonstrating third party certification with these requirements.
- C. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Gaskets:
 - 1. Garlock Mechanical Packing Division
 - 2. Manville

- B. Dielectric fittings:
1. Anvil International
 2. Elster Perfection
 3. Precision Plumbing Products, Inc.
 4. Sioux Chief Manufacturing Company, Inc.
 5. Victaulic Company of America
- C. Water strainers:
1. Ames
 2. Febco
 3. Mueller Steam Specialty
 4. Spirax Sarco Inc.
 5. Tate Andale, Inc. "Guardian"
 6. Watts Industries, Inc.
 7. Zurn-Wilkins
- D. Backflow preventers:
1. Zurn Wilkins
 2. Febco Division of CMB Industries
 3. Ames Division of Watts Water Technologies
 4. Apollo Valves
- E. High-capacity automatic air vents:
1. Amtrol Inc.
 2. Hoffman Specialty Div. of ITT Industries
 3. Spirax Sarco Inc.
 4. Spirotherm, Inc.
 5. Taco, Inc.
- F. Water hammer arrestors:
1. Zurn Plumbing Products
 2. Jay R. Smith Manufacturing Company
 3. Josam Company
 4. MIFAB Inc.
 5. Wade
 6. Watts Drainage
- G. Thermostatic mixing valves:
1. Bradley Corporation
 2. Lawler Manufacturing Company Inc.
 3. Leonard Valve Company
 4. Powers Regulator Company
 5. Symmons Industries Inc.
- H. Trap primers:
1. Jay R. Smith Manufacturing Company

2. MIFAB Inc.
3. Precision Plumbing Products
4. Sloan Valve
5. Watts Industries
6. Zurn Plumbing Products

I. Water pressure reducing valves:

1. Spence Engineering Company Inc.
2. Watts Industries Inc.

2.21 GASKETS AND UNIONS

- A. Gaskets for flanged joints: Cross-laminated long fiber composition suitable for service, temperature, pressure and liquid with which they come in contact.
- B. Unions NPS 2.5 (DN 65) and smaller: Malleable iron, Class 150, ASME B16.39, equal to Anvil International with ground bronze seats, or soldered type brass unions of equal quality.

2.22 DIELECTRIC FITTINGS

- A. General: Completely isolate dissimilar metals so that electric current is below 1 percent of the galvanic current which would exist with metal-to-metal contact. Gaskets approved for the medium carried by the piping system.
- B. Dielectric nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain or threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 degrees F (107 degrees C).
- C. Grooved piping: "Dielectric Waterway Fittings" equal to Victaulic Co. "Clearflow" steel threaded ends or thread to Victaulic groove with opaque, high-temperature thermoplastic copolymer liner designed for use at temperatures up to 225 degrees F (107 degrees C) and pressure up to 300 psi (2068 kPa). Complete with ring groove to lock steel casing to plastic liner.

2.23 WATER SPECIALTIES

- A. Basket-type water strainers: Epoxy-coated cast iron, flanged, equal to Mueller Steam Specialty No. 165, and meeting working pressure ratings published by Mueller. Basket: stainless steel screen with 1/8-inch (3-mm) perforations.
- B. Y-type strainers:
 1. Equal to Spirax Sarco Model IT threaded or Model CI flanged.
 2. For use in copper piping: Watts lead free brass Model LF777SI threaded.
 3. Screens in Y-type strainers: Stainless-steel having maximum 0.045-inch (1.2-mm) perforations.
- C. Backflow preventer for domestic water service: ASSE 1013, reduced-pressure-principle type, complete with dual check valves, relief valves assembly, tri-cocks, and stop valves.
- D. Backflow preventer for fire suppression service: ASSE 1047, reduced-pressure-principle type, detector assembly, complete with strainer, dual check valves, test cocks, and stop valves. Assembly shall be UL and FM approved for fire service.

- E. High-capacity automatic air vent: For releasing air from hot or cold water lines. Float-operated type with minimum 7 cfm (3.3 L/s) capacity.
 - 1. Materials: Cast-iron body and cover; stainless-steel valve pin and seat, and float; gasket conforming to ASTM F 104; high-strength steel cap screws.
 - 2. Operating limits: Maximum pressure 250 psig (1725 kPa); maximum temperature 300 degrees F (149 degrees C); hydrostatic pressure to 350 psig (2415 kPa).

- F. Water hammer arrestors: ASSE 1010 or PDI WH-201 certified, equal to Zurn "Shoktrol" Z-1700:
 - 1. Construction: Metal bellows or copper tube with piston.
 - 2. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

- G. Thermostatic mixing valves: Utilize at domestic water heater:
 - 1. ASSE 1017, equal to Powers Regulator Company "Hydroguard" – LFSH1430.
 - 2. Integral checks and screen strainers at inlets.
 - 3. Threaded or soldered connections.
 - 4. Discharge temperature adjustment range: 90 degrees F – 160 degrees F, set at 120 degrees F.
 - 5. Rigid bulb indicating thermometer at supply outlet; 3-inch dial graduated 30 degrees to 130 degrees F, stainless steel, hermetically sealed with external calibration screw.
 - 6. Minimum flow: 0.5 gpm, with continuous recirculating pump.

- H. Trap primers:
 - 1. Water closet vacuum breaker trap primer: ASSE 1044, vacuum breaker assembly with chrome-plated fittings and chrome-plated flexible copper tubing and wall flange. Provide product equal to Sloan Valve Company Model VBF-72-A.
 - 2. Automatic inline Trap primer valve: ASSE 1044, equal to Precision Plumbing Products "Mini-Prime Electronic Trap Priming System," factory assembled unit consisting of the following:
 - a. Pre-set 24-hour timer that actuates a solenoid valve 6 seconds every 24 hours providing 2.0 ounces discharge at 20 psi inlet pressure.
 - b. NPS 0.50 (DN 15) copper inlet connection.
 - c. NPS 0.50 (DN 15) copper outlet connection.
 - d. Distribution Unit: Connects directly to the primer valve with up to four 0.375-inch compression outlet fittings for NPS 0.50 (DN 15) copper tubing.
 - e. Provide a steel box and accessible cover.
 - f. Electrical: 120 volt, single phase, 60 Hertz, single-point power supply, circuit breaker, manual override switch and test button.
 - 3. Automatic trap priming panel: ASSE 1044, equal to Precision Plumbing Products "Prime-Time Electronic Trap Priming System," factory assembled unit consisting of the following:
 - a. Pre-set 24-hour timer that actuates a solenoid valve 6 seconds every 24 hours providing 2.0 ounces discharge at 20 psi inlet pressure.
 - b. NPS 0.75 (DN 20) copper inlet connection with bronze ball type shutoff valve.

- c. NPS 0.75 (DN 20) supply manifold with ASSE 1001 atmospheric vacuum breaker, 0.625-inch compression outlet fittings for NPS 0.50 (DN 15) copper tubing. Provide one outlet for each floor to be primed. Manifold assembly shall be calibrated for equal water distribution.
 - d. Provide a steel-surface-mounted cabinet with access cover where concealed above ceilings or mounted in mechanical rooms.
- I. Pressure relief valves: ASME rated, NB approved, automatic reseating type conforming to ANSI Z21.22.
- 1. Provide straight pressure type where installed in pipe lines and for protection of coils and cold water vessels.
 - 2. Provide combination pressure and temperature type where installed for hot water tanks and vessels.
- J. Water pressure-reducing valves: Equal to Zurn-Wilkins 500XL, direct acting with integral bypass:
- 1. Construction: Bronze body and stainless-steel seat, FDA approved elastomers.
 - 2. Pressure rating: Maximum working water pressure of 300 psig (2070 kPa).
 - 3. Temperature rating: Maximum working water temperature of 140 degrees F.
 - 4. Pressure range: 25 psi to 75 psi (172 to 517 kPa).
 - 5. Size: NPS 3.0 (DN 80) or smaller.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Plastic piping specialties are not permitted in HVAC system ceiling plenums or shafts used to convey building HVAC air distribution.

3.23 INSTALLING GASKETS AND DIELECTRIC FITTINGS

- A. Gaskets shall be installed in accordance with manufacturer's recommendations.
- B. Pipe connections to fixtures, control valves, equipment and appliances shall be provided with unions or flanges so that the units may be disconnected and replaced without damage to the pipe.
- C. Provide dielectric fittings between copper and steel piping NPS 0.5 through 2.5 (DN 15 through 65).

3.24 INSTALLING WATER SPECIALTIES

- A. Provide specialties for each piping system, as indicated.
- B. Strainers at domestic service entrance shall be basket type. Install y-pattern strainers on the supply side of each control valve, water pressure reducing valve, inline pump, and where indicated on drawings.
- C. The water pressure-reducing valves and pressure relief valves shall be line size and adjusted to the pressures indicated on the drawings.

- D. Provide backflow preventers with Y strainers; if required for service entrance, provide basket type strainer.
- E. Install relief valves for water heaters and other devices where required by governing codes. Relief valve discharge shall be piped as indicated or to the nearest floor drain or to within six inches of the floor beside unit.
- F. Install water pressure-reducing valve in water service at point of entry into building arranged as indicated. Install bypass with globe valve as shown on drawings. Provide pressure gage on each side of the pressure-reducing valve.
- G. Automatic fill for the hydronic systems shall be as diagramed on the drawings. The pressure-reducing valves and pressure-relief valves shall be line size and adjusted to the pressures indicated on the drawings.
- H. Install backflow preventers in the building water supply, each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Mount 48 inches (1219 mm) above the floor unless otherwise noted on the drawings. Comply with the authorities having jurisdiction.
 - 1. Install drains for backflow preventers with atmospheric-vent drain connections with air-gap fitting, and pipe as indicated on the drawings. Do not install bypass piping around backflow preventers.
- I. Trap primers:
 - 1. Install flush valve vacuum breaker trap primers for floor drains in toilet rooms.
 - a. Priming line shall be taken from the valve vacuum breaker of the nearest water closet to the floor drain to be primed.
 - b. Provide one primer for each floor drain.
 - 2. Install automatic trap primers where indicated on the drawings.
 - 3. Install a shutoff valve in the branch line serving each primer valve or system.
 - 4. Install trap primer assemblies level and plumb to ensure equal flow distribution to the primer lines or distribution unit.
 - 5. Run primer outlet piping concealed with NPS 0.5 (DN 15) soft drawn copper pipes pitch down toward drains at minimum 1.0 percent slope and connect to floor drain trap primer fittings.
 - a. Install type L copper tubing except Type K copper where installed below floor slabs on earth.
- J. Installing water hammer arrestors: Size and locate water hammer arrestors as recommended by the Plumbing and Drainage Institute Standard PDH –WH 201 or ASSE 1010.
 - 1. Install water hammer arrestors in each branch domestic water pipe (hot and cold) which feeds either a battery of fixtures or a single fixture. Install water hammer arrestors upstream of quick-closure valves.

- K. Installing thermostatic mixing valves: Connect as shown as shown on the drawings and in compliance with the manufacturer's recommendations for two temperature hot water recirculating system.

END OF SECTION 221119

SECTION 221123 - DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.11 WORK INCLUDED

- A. In-line circulator.

1.14 RELATED SECTIONS

- A. Motors: Section 220513.
- B. Controls: Sections 230901 through 230923.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Product data: Include certified performance curves and rated capacities of selected models; shipping, installed, and operating weights; furnished specialties; and accessories for each type and size of pump specified. Indicate pumps' operating point on curves.
 - 1. Certification that products comply with NSF/ANSI 61 and NSF/ANSI 372.
- C. Shop drawings: Show layout and connections for pumps. Include setting drawings with templates, directions for installation of foundation and anchor bolts, and other anchorages.
 - 1. Wiring diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.
- D. Maintenance data: For each pump specified, to include in maintenance manuals specified in Division 01 and Section 220101.

1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 220500, Common Work Results for Plumbing.
- B. Potable water system components intended to dispense water for human consumption, including pipe and joining materials, shall comply with the following:
 - 1. A weighted average lead content of not more than 0.25 percent as determined by NSF/ANSI 372.
 - 2. NSF/ANSI 61.
- C. Acceptance product marking: NSF®-61 and NSF®-372 (or NSF®-61-G) or other accepted certifier marks demonstrating third party certification with these requirements.
- D. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Specified units are the basis for design of the project. The following listed manufacturers also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article "Product Options" in Section 220101, and submit shop drawings as specified in article 1.30 above.
- B. In-line pumps (circulators):
 - 1. Armstrong Pumps Inc.
 - 2. Bell and Gossett Domestic Pump, ITT Industries
 - 3. Deming, Crane Pumps and Systems
 - 4. Paco Pumps; Grundfos Group
 - 5. Patterson Pump Co.
 - 6. Taco Inc.

2.23 IN-LINE PUMPS (DOMESTIC HOT WATER CIRCULATORS)

- A. Equal to Taco Inc. Series 00 cartridge type circulator of size scheduled on the drawings. "Low lead" bronze or stainless steel body, stainless-steel cartridge with non-metallic impeller, ceramic shaft, carbon bearings and EPDM seals.

PART 3 - EXECUTION

3.25 INSTALLING IN-LINE DOMESTIC WATER CIRCULATOR

- A. In-line pumps shall be provided where indicated and shall be installed with motor in horizontal position. Provide necessary bracket to building construction to support the pump and reduce vibration in pipe work.

3.70 ADJUST AND CLEAN

- A. Set pump controls for specified operation.
- B. Before starting, perform preventive maintenance:
 - 1. Lubricate bearings.
 - 2. Disconnect couplings and inspect motors for proper direction of rotation.
 - 3. Verify that each pump rotates freely by hand. If it is bound or drags, determine the cause and correct it.
 - 4. Verify that pump controls are correct for the application.

3.80 STARTUP

- A. Start motors.
- B. Open discharge valves only.
- C. Check general mechanical operations of systems and motors.

END OF SECTION 221123

SECTION 22 13 13 - FACILITY SANITARY SEWERS

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 sanitary sewer systems outside the building.

1.3 DEFINITIONS

- A. CIP: Cast iron soil pipe.
- B. CIPX Extra-heavy cast iron soil pipe.
- C. PVC: Polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

- A. Gravity-Flow, Non-pressure-Piping Pressure Ratings: At least equal to system test pressure.

1.5 SUBMITTALS

- A. Product Data: For the following:
 - 1. Pipe and fittings.
 - 2. Cleanouts.
- B. Shop Drawings: Include plans, elevations and details for the following:
 - 1. Precast concrete manholes and other structures, including frames, covers, and grates.
 - 2. Cast-in-place concrete structures, including frames, covers, and grates.
- C. Design Mix Reports and Calculations: For each class of cast-in-place concrete.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic pipe, and fittings in direct sunlight.
- B. Protect pipe, pipe fittings, and seals from dirt and damage.

- C. Handle precast concrete manholes and other structures according to manufacturer's written rigging instructions.

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 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's Representative not less than fourteen days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Owner's Representative's written permission.

1.8 QUALITY ASSURANCE

- A. Material and Installation Specifications; Baltimore County, Department of Public Works Standard Specifications for Construction and Materials, (BCDPW), February 2000, as amended to date. Delete references to "Measurement and Payment"
- B. Standard Details: BCDPW Standard Details for Construction, April 2010, as amended to date.
- C. Baltimore County Plumbing Code, as amended to date.

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. Gray-Iron Cleanouts:
 - a. Josam Co.
 - b. McWane, Inc.; Tyler Pipe; Wade Div.
 - c. MIFAB.
 - d. Smith: Jay R. Smith Mfg. Co.
 - e. Watts Industries, Inc.; Ancon Drain Div.
 - f. Watts Industries, Inc.; Enpoco, Inc. Div.
 - g. Zurn Industries, Inc.; Hydromechanics Div.
 - 2. PVC Cleanouts:
 - a. Canplas, Inc.

- b. IPS Corp.
- c. NDS, Inc.
- d. Plastic Oddities, Inc.
- e. Sioux Chief Manufacturing Co., Inc.

2.2 PIPING MATERIALS

- A. Refer to Part 3 for applications of pipe and fitting materials.

2.3 PIPES AND FITTINGS

- A. Hub-and-Spigot, Cast-Iron Soil Pipe and Fittings: ASTM A 74, gray iron, for gasketed joints.
 - 1. Gaskets: ASTM C 564, rubber, compression type, thickness to match class of pipe.
- B. PVC Pipe and Fittings: In accordance with Baltimore County Plumbing Code and the following:
 - 1. PVC Pipe and Fittings, (ASTM D 3034, SDR 26 or heavier, PS-46 or stiffer, ASTM F 679) and DWV (ASTM D 2665) Pipe and Fabricated Fittings, NPS 4 to 12-inch, for solvent-cemented or gasketed joints.
 - a. Gaskets: ASTM F 477, elastomeric seals.

2.4 SPECIAL PIPE COUPLINGS AND FITTINGS

- A. Sleeve-Type Pipe Couplings: ASTM C 1173, rubber or elastomeric sleeve and band assembly fabricated to mate with OD of pipes to be joined, for nonpressure joints.
 - 1. Sleeve Material for Concrete Pipe: ASTM C 443, rubber.
 - 2. Sleeve Material for Cast-Iron Soil Pipe: ASTM C 564, rubber.
 - 3. Sleeve Material for Plastic Pipe: ASTM F 477, elastomeric seal.
 - 4. Sleeve Material for Dissimilar Pipe: Compatible with pipe materials being joined.
 - 5. Bands: Stainless steel, at least one at each pipe insert.
- B. Bushing-Type Pipe Couplings: ASTM C 1173, rubber or elastomeric bushing fabricated to mate with OD of smaller pipe and ID of adjoining larger pipe, for nonpressure joints.
 - 1. Material for Concrete Pipe: ASTM C 443, rubber.
 - 2. Material for Cast-Iron Soil Pipe: ASTM C 564, rubber.
 - 3. Material for Plastic Pipe: ASTM F 477, elastomeric seal.
 - 4. Material for Dissimilar Pipe: Compatible with pipe materials being joined.

2.5 MANHOLES AND SPECIAL STRUCTURES

- A. Normal-Traffic Precast Concrete Manholes: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for rubber gasketed joints, in accordance with BCDPW specifications and standard details.
 - 1. Diameter: 48 inches minimum, unless otherwise indicated.

2. Base Section: 4-inch minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.
 3. Riser Sections: 4-inch minimum thickness 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. Gaskets: ASTM C 443, rubber.
 6. Grade Rings: Include two or three reinforced-concrete rings, of 6- to 9-inch total thickness, that match 24-inch- diameter frame and cover.
 7. Steps: Cast Iron, individual steps or ladder. Include width that allows worker to place both feet on one step and is designed to prevent lateral slippage off step. Cast or anchor into base, riser, and top section sidewalls with steps at 12- to 16-inch intervals. Omit steps for manholes less than 60 inches deep.
 8. Steps: ASTM C 478, individual steps or ladder.
 9. Pipe Connectors: ASTM C 923, resilient, of size required, for each pipe connecting to base section.
- B. Manhole Frames and Covers in accordance with BCDPW specifications, designed for heavy-duty service. Include top design with lettering cast into cover.
1. Frames and Covers with manufacturer's designation "Heavy Duty".
 - a. Material: Gray iron.

2.6 CLEANOUTS

- A. Gray-Iron Cleanouts: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-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 and along main service access walk.
- B. PVC Cleanouts: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earthwork."

3.2 IDENTIFICATION

- A. Materials and their installation are specified in Division 31 Section "Earthwork." Arrange for installing green warning tapes directly over piping and at outside edges of underground structures.

1. Use warning tape or detectable warning tape over ferrous piping.
2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.3 PIPING APPLICATIONS

- A. General: Install watertight joints.
- B. Refer to Part 2 of this Section for detailed specifications for pipe and fitting products listed below. Use pipe, fittings, and joining methods according to applications indicated.
- C. Gravity-Flow Piping: Use the following, with type and class as indicated on the drawings:
 1. NPS 3 to NPS 6: Hub-and-spigot, Extra-Heavy class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 2. NPS 4 to NPS 8: PVC sewer pipe and fittings, solvent-cemented joints, or gaskets and gasketed joints.

3.4 SPECIAL PIPE COUPLING AND FITTING APPLICATIONS

- A. Special Pipe Couplings: Use where required to join piping and no other appropriate method is specified. Do not use instead of specified joining methods.
 1. Use the following pipe couplings for nonpressure applications:
 - a. Sleeve type to join piping, of same size, or with small difference in OD.
 - b. Increaser/reducer-pattern, sleeve type to join piping of different sizes.
 - c. Bushing type to join piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.

3.5 INSTALLATION, GENERAL

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take design considerations into account. Install piping with fittings and cleanouts as indicated, to extent practical, in accordance with BCDPW specifications and the Baltimore County Plumbing Code.
- B. Install piping beginning at low point, 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 written instructions 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. Install manholes at changes in direction, unless fittings are indicated. Use fittings for branch connections, unless direct tap into drain is indicated.
- D. Use proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

- E. Install gravity-flow piping and connect to building's sanitary drains, of sizes and in locations indicated. Temporarily terminate piping as indicated.
- F. Extend piping and connect to building's sanitary drains, of sizes and in locations indicated. Temporarily terminate piping as indicated.

3.6 PIPE JOINT CONSTRUCTION AND INSTALLATION

- A. General: Join and install pipe and fittings according to installations indicated.
- B. Hub-and-Spigot, Cast-Iron Soil Pipe and Fittings: With rubber gaskets according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook." Use gaskets that match class of pipe and fittings.
- C. Install with top surfaces of cleanouts flush with finished surface of paving.
- D. PVC Sewer Pipe and Fittings: As follows:
 - 1. Join pipe and gasketed fittings with gaskets according to ASTM D 2321.
 - 2. Install according to ASTM D 2321.
- E. System Piping Joints: Make joints using system manufacturer's couplings, unless otherwise indicated.
- F. Join piping made of different materials or dimensions with couplings made for this application. Use couplings that are compatible with and that fit both systems' materials and dimensions.

3.7 MANHOLE AND SPECIAL STRUCTURES INSTALLATION

- A. General: Install structures, complete with appurtenances and accessories indicated.
- B. Construct continuous channels and benches between inlets and outlet.
- C. Set tops of frames and covers flush with finished surface of adjoining pavement. Set tops flush with finished surface elsewhere, or in accordance with Baltimore County Plumbing Code.
- D. Install precast concrete manhole sections with gaskets according to ASTM C 891.

3.8 CONCRETE PLACEMENT

- A. Place cast-in-place concrete according to ACI 318 and ACI 350R.

3.9 CLEANOUT INSTALLATION

- 1. Install cleanouts in accordance with BCDPW specifications and the Baltimore County Plumbing Code.
- B. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Install piping so cleanouts open in direction of flow in storm drain pipe.

- C. Set cleanout frames and covers in lawn and plant bed areas in cast-in-place concrete block, 18 by 18 by 12 inches deep. Set with tops 1 inch above surrounding earth grade.
- D. Set cleanout frames and covers in concrete pavement with tops flush with pavement surface.

3.10 TAP CONNECTIONS

- A. Make connections to existing piping and underground structures so finished Work complies as nearly as practical with requirements specified for new Work.
- B. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting, plus 6-inch overlap, with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
- C. Make branch connections from side into existing piping, NPS 4 to NPS 10. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
- D. Protect existing piping and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

3.11 CLOSING ABANDONED SANITARY SEWER SYSTEMS

- A. Abandoned Piping: Close open ends of abandoned underground piping 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 procedure below:
 - 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. Structures: Remove all existing structures, including septic tanks and distribution boxes.
 - 1. Remove structure and piping.
 - 2. Backfill to grade according to Division 31 Section "Earthwork".

3.12 FIELD QUALITY CONTROL

- A. Clear interior of piping and structures of dirt and superfluous material as 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 when work stops.
 - 3. Flush piping between manholes and other structures to remove collected debris, if required by authorities having jurisdiction.
- 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 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 visible between structures.
 - b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of 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 referenced codes and specifications.
 3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
 4. Submit separate reports for each test.
 5. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

END OF SECTION 22 13 13

SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Sanitary piping, interior and exterior.

1.14 RELATED SECTIONS

- A. Piping installation and testing: Section 220500

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Product data: Each specified material and product.
- C. Submit shop drawings showing proposed configuration of new connections in existing manholes.

1.40 QUALITY ASSURANCE

- A. Cast iron pipe and fittings shall be marked with the collective trademarks of the Cast Iron Soil Pipe Institute (CISPI) and listed by NSF International.
- B. Prior to any new piping installation, the Contractor shall verify the inverts of all piping to which new work is to be attached. The Contractor shall demonstrate to the satisfaction of the construction manager and/or Owner, that the connections to existing sanitary pipes meet the intent of the contract.
- C. Pipe shall be certified by the manufacturer to meet referenced standards and shall bear a label, directly on the pipe, indicating compliance.
- D. The Contractor shall rod, clean, and flush existing sanitary piping as necessary to maintain gravity flow.

PART 2 - PRODUCTS

2.20 PIPING AND FITTINGS, TYPES

- A. Install each type of pipe and fittings in locations required or permitted in Part 3, including the Pipe Installation Schedule at the end of the section.
- B. Type A: Cast-iron hub and spigot pipe and fittings, ASTM A 74 service class, with lead and oakum joints.
- C. Type B: Cast-iron hub and spigot pipe and fittings, ASTM A 74 service class, with lifetime neoprene gasket joints, ASTM C 564, equal to Fernco "Multi-Tite", Tyler Pipe "Ty-seal", or Mission Rubber "Mission-Tite."
- D. Type C: Cast-iron no-hub pipe, Cast Iron Soil Pipe Institute Standard 301. Neoprene gaskets: ASTM C 564. Stainless steel: Type 304.

1. Fittings assembled with neoprene gaskets and 24-gage stainless-steel housing with two stainless-steel bolted clamps, except as specified in paragraph 2 below.
 2. Where couplings will be inaccessible, or pipe is exposed, fittings assembled with neoprene gaskets and two-piece cast-iron housing clamps and stainless-steel bolts and nuts equal to products of MG Piping Products Co.; or with corrugated 304 stainless-steel shields with four or six clamps and holding bolts conforming to ASTM C 1540 and rubber gasket sealing sleeves conforming to ASTM C 564, equal to "Husky Series 4000" coupling or Mission "Heavy Weight Series CHW" coupling.
 3. Pipe and fitting restraints for piping NPS 5 (DN 125) and larger: Equal to Holdrite No. 117 No-Hub Pipe and Fitting Restraint. Factory fabricated pipe and fitting restraint assemblies rated to prevent pipe separation under fluid thrust forces up to 50 feet of head. Comply with CISPI 301, latest edition.
- E. Type D: Copper tubing Type DWV, ASTM B 306, with wrought copper drainage fittings and soldered joints, ANSI B16.29; or cast-brass fittings, ANSI B16.23.
- F. Type F: Extra-heavy cast-iron hub and spigot pipe and fittings, ASTM A 74.
- G. Type I: PVC DWV pipe and fittings:
1. Pipe: PVC, Schedule 40, ASTM D 1785.
 2. Fittings: PVC, DWV, ASTM D 2665.
 3. Solvent cement: PVC, ASTM D 2564.

PART 3 - EXECUTION

3.05 PREPARATION

- A. Connect piping to stubs as shown on the drawings. Check elevations of these connection points before installing new work.

3.10 INSTALLATION, GENERAL

- A. Use suitable tools and appliances for the safe and convenient handling and laying of pipe. Examine each section of pipe for defects. Do not lay any piece that is known to be defective. If any defective piece should be discovered after having been laid, remove and replace it at no change to the contract price.
- B. Install piping in accordance with the Pipe Installation Schedule at the end of this section, as indicated on the drawings, and in accordance with Section 220500, Common Work Results for Plumbing. Materials and work shall conform to local plumbing codes and health department regulations.
- C. Thoroughly clean all pipe and fittings before installing them, and keep them clean until the acceptance of the completed work. Cap or plug ends of lines to prevent debris from entering during construction.
- D. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
1. Join hub and spigot cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

2. Join hub and spigot cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints. Fill joints with lead to a depth of at least 1 inch, and make it flush with the hub of the Pipe.
3. Join no-hub (hubless), cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless piping coupling joints.
 - a. Install restraint assemblies at pipe couplings and fittings for piping NPS 5 (DN 125) and larger.
- E. Install aboveground copper tubing according to Copper Development Association, Inc. (CDA) "Copper Tube Handbook."
- F. Install aboveground PVC piping according to ASTM D 2665.
- G. Install underground PVC piping according to ASTM D 2321.
- H. Make changes in direction of sanitary piping with approved sanitary fittings, Y branches, 1/8 or 1/16 bends.
- I. In soil, waste, and vent stacks where branches occur that are smaller than stacks, provide properly sized reducing fittings.
- J. Install all sanitary piping at a 2 percent minimum downward slope in the direction of flow unless otherwise indicated.
- K. Install vent piping at a 1 percent slope down toward vertical fixture vent or toward vent stack.

3.21 RESTRICTIONS ON LOCATIONS

- A. Cast-iron hub and spigot piping with lead joints (Type A), and cast-iron, no-hub piping (Type C) are not permitted over food preparation, storage, serving, or dining areas.
- B. Plastic piping above ground (Type I):
 1. Not allowed in HVAC ceiling plenums or shafts used to convey building air distribution where not rated for that application.
 2. Require special protection designed for plastic piping penetrations where they occur in fire-rated assemblies or floors.

3.90 SCHEDULES

(See Schedule, next page)

SANITARY PIPE INSTALLATION SCHEDULE Contractor has option where more than one x appears on a line						
MATERIAL TYPE						
USE	A	B	C	D	F	I
Sanitary, exterior	X	X			X	X
Sanitary, below slab on earth	X	X				X
Sanitary, concealed within walls or partitions	X		X	X		X
Sanitary, ceiling space	X		X	X		X
Sanitary, interior exposed	X		X	X		X
Miscellaneous drains from equipment			X	X		X
Radon vent, below slab on earth	X	X				X
Radon vent, above grade.	X		X			X

ALL OF THE ABOVE SUBJECT TO LOCAL PLUMBING CODE AND HEALTH DEPARTMENT REQUIREMENTS

MATERIAL TYPES (Refer to Part 2 - Products)

- A - Cast iron hub & spigot, lead joint
- B - Cast iron hub & spigot, rubber joint
- C - Cast iron no hub
- D - Copper DWV
- F - Extra heavy cast-iron, lead joint
- I - PVC DWV

END OF SECTION 221316

SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Drains and cleanouts.
- B. Flashing material.
- C. Solids and grease interceptors.

1.14 RELATED SECTIONS

- A. Piping: Section 221316.
- B. Curbs and flashings: Section 220506.
- C. Insulation: Section 220719.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Product data: Each specialty device or equipment, with installation instructions.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. General: Model numbers are provided in the articles below to set a standard for materials, quality of construction, options and details, and performance. Provide named products, or equal products by the acceptable manufacturers listed.
- B. Drains and cleanouts:
 - 1. Josam Company
 - 2. Jay R. Smith Manufacturing Company
 - 3. MIFAB, Inc.
 - 4. Wade
 - 5. Watts Drainage
 - 6. Zurn Plumbing Products
- C. Grease interceptors:
 - 1. Bacterial:
 - a. Jay R. Smith

2.21 FLOOR DRAINS AND FLOOR SINKS

- A. Equal to the Zurn catalog numbers noted on drawings. Those installed in slabs on grade and above crawl space do not require flashing clamp devices. All others shall have flashing clamp devices.
- B. Floor drain P traps shall be deep seal type and shall have primer plugs.
- C. Floor sinks shall have acid-resistant porcelain enamel interior finish with internal aluminum dome strainers.

2.22 FLEXIBLE FLASHING

- A. Flexible polyvinyl chloride sheet, waterproof and impermeable to water vapor, unreinforced, minimum 56 mils thick, recommended for use in concealed locations only.
- B. Shows no physical deterioration when tested in accordance with ASTM D 822 for at least 400 hours.
- C. Shows no cracking or flaking when, at -20 degrees F (-6.5 degrees C), it is bent 180 degrees over a 0.03125-inch (0.8-mm) mandrel and back 360 degrees over the same mandrel in the opposite direction.
- D. Has no less than 1000 lbs. per sq. in. (6900 kPa) tensile strength and no more than 7 percent tension set at 50 percent elongation, when tested in accordance with ASTM D 412.
- E. Products which meet this specification include but are not limited to:
 - 1. Advanced Building Products "Moistseal"
 - 2. Afco Products Company "Vi-Seal"
 - 3. York Manufacturing, Inc. "Wascoseal"

2.23 CLEANOUTS

- A. Cleanouts: Equal to following Zurn Catalog numbers. Those installed in slab on grade and in slab above crawl spaces do not require membrane flashing device. All others shall have flashing devices.
- B. In sanitary lines:
 - 1. Exposed piping: Z-1445 with bronze cleanout plug.
 - 2. Concealed piping: ZN-1446-BP with bronze cleanout plug.
 - 3. Concealed piping where more than 8 inches (205 mm) back from finished wall line: Install a sanitary 90 degrees long turn Y fitting with bronze cleanout plug extended out to finish 1 inch (25 mm) behind finished wall. Provide with Z-1460-9x9 cover plate (access panel) with vandalproof screws.
- C. In underfloor sanitary lines: (See Floor Finish Schedule) All units complete with bronze plug.
 - 1. In storage areas with plain or painted concrete floors: ZB-1400.
 - 2. In exposed areas with plain or painted concrete floors: ZN-1400.
 - 3. In resilient tile floors: ZN-1400-TX.
 - 4. In ceramic tile floors: ZN-1400-T.

5. In carpeted floors: ZN-1400-CM.
6. In terrazzo floors: ZN-1400-DC.

D. Outside cleanouts shall be ZN-1400-HD with vandalproof screws.

2.24 BACTERIAL GREASE INTERCEPTOR

- A. Jay R. Smith 8970 Series "Remediator" stainless-steel grease treatment system, tested and certified in accordance with PDI G101 as a fats, oils, and grease (FOG) disposal system discharging 100 mg/l or less of FOG.
- B. Flow rating: 75 gpm.
- C. FOG capacity: 75 lbs.
- D. Treatment chamber: Designed to bring FOG in contact with bacteria, in the presence of oxygen.
- E. Components: Microprocessor-controlled metering pump, low supply alarm, external flow-control fitting, culture reservoir.
 1. Bacterial culture: Liquid containing nonpathogenic species of bacteria which digest FOG and complex hydrocarbons, producing carbon dioxide and water.
- F. Solids interceptor: Stainless steel, with stainless-steel mesh-lined basket and flat cover, capable of removing more than 90 percent of solids larger than 2 mm.

PART 3 - EXECUTION

3.21 INSTALLING FLOOR DRAINS AND FLOOR SINKS

- A. Where floor drains are over occupied areas, flash them with flashing specified in this section, single piece for each drain, 30 by 30 inches (762 by 762 mm) with opening cut in center to suit clamping device of drain. Adhere flashing to substrate with adhesive and secure to clamping device of drain. Ascertain that weep holes from drainage pan are open.
- B. Generally, the rims of floor drains and sinks shall be set 1 inch (25 mm) below specified floor finish level and the floor sloped to the drain so as to finish flush with the rim.
- C. Floor drains and floor sinks shall be provided with deep seal cast-iron P traps with primer connections, including those discharging directly into storm drains.
- D. Floor drains and floor sinks shall be provided with trap primers.
 1. Refer to Section 221119, Domestic Water Piping Specialties, for trap primers.
- E. Floor drains shall be covered until placed in service to prevent the entrance of any foreign matter.

3.22 INSTALLING CLEANOUTS

- A. Install cleanouts at base of each vertical, soil, waste, and vent stack, in the vertical piping.
- B. Cleanouts shall be the same size as the pipe into which they are installed, except no cleanout shall be larger than NPS 4 (DN 100).

- C. Install cleanouts in horizontal piping where indicated on drawings. Where cleanouts occur directly below a floor, the cleanout shall terminate with top flush with floor. Provide for the floor finish to be installed on the cleanout cover, and separated from surrounding material. Install carpet markers after carpet installation is completed. Install ceramic tile and terrazzo per manufacturer's instructions.
- D. Where cleanouts are over occupied areas, flash them with flashing specified in this section, single piece for each cleanout, 30 by 30 inches with opening cut in center to suit clamping device of cleanout. Adhere flashing to substrate with adhesive and secure to clamping device of cleanout.
- E. Cleanouts on exterior lines: Extend up flush with finish grade and support in a concrete pad, 18 by 18 inches (460 by 460 mm), 8 inches (205 mm) thick, reinforced with 6 by 6-inch (50 by 50-mm) No. 6 wire mesh.

3.23 INSTALLING GREASE INTERCEPTORS

- A. Install between waste lines and sanitary sewer connection as shown on the drawings.
- B. Install bacterial interceptor in accordance with manufacturer's instructions and as indicated on the drawings. Mount approved operating and maintenance instructions in a frame with clear plastic protection cover securely to wall beside unit with four tamperproof screws.

END OF SECTION 221319

SECTION 221413 - STORM DRAINAGE PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Air-conditioning condensate drain.
- B. Storm piping.
- C. Foundation drain.

1.14 RELATED SECTIONS

- A. Piping installation and testing: Section 220500.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Product data: Each specified material and product.

1.40 QUALITY ASSURANCE

- A. Cast iron pipe and fittings shall be marked with the collective trademarks of the Cast Iron Soil Pipe Institute (CISPI) and listed by NSF International.
- B. Prior to any new piping installation, the Contractor shall verify the inverts of all piping to which new work is to be attached. The Contractor shall demonstrate to the satisfaction of the construction manager and/or Owner, that the connections to existing storm pipes meet the intent of the contract.
- C. Pipe shall be certified by the manufacturer to meet referenced standards and shall bear a label, directly on the pipe, indicating compliance.
- D. The Contractor shall rod, clean, and flush existing storm piping as necessary to maintain gravity flow.

PART 2 - PRODUCTS

2.20 PIPING AND FITTINGS, TYPES

- A. Install each type of pipe and fittings in locations required or permitted in Part 3, including the Pipe Installation Schedule at the end of the section.
- B. Type A: Cast-iron hub and spigot pipe and fittings, ASTM A 74 service class, with lead and oakum joints.
- C. Type B: Cast-iron hub and spigot pipe and fittings, ASTM A 74 service class, with lifetime neoprene gasket joints, ASTM C 564, equal to Fernco "Multi-Tite", Tyler Pipe "Ty-seal", or Mission Rubber "Mission-Tite."
- D. Type C: Cast-iron no-hub pipe, Cast Iron Soil Pipe Institute Standard 301. Neoprene gaskets: ASTM C 564. Stainless steel: Type 304.

1. Fittings assembled with neoprene gaskets and 24-gage stainless-steel housing with two stainless-steel bolted clamps, except as specified in paragraph 2 below.
 2. Where couplings will be inaccessible, or pipe is exposed, fittings assembled with neoprene gaskets and two-piece cast-iron housing clamps and stainless-steel bolts and nuts equal to products of MG Piping Products Co.; or with corrugated 304 stainless-steel shields with four or six clamps and holding bolts conforming to ASTM C 1540 and rubber gasket sealing sleeves conforming to ASTM C 564, equal to "Husky Series 4000" coupling or Mission "Heavy Weight Series CHW" coupling.
 3. Pipe and fitting restraints for piping NPS 5 (DN 125) and larger: Equal to Holdrite No. 117 No-Hub Pipe and Fitting Restraint. Factory fabricated pipe and fitting restraint assemblies rated to prevent pipe separation under fluid thrust forces up to 50 feet of head. Comply with CISPI 301, latest edition.
- E. Type D: Copper tubing Type DWV, ASTM B 306, with wrought copper drainage fittings and soldered joints, ANSI B16.29; or cast-brass fittings, ANSI B16.23.
1. For air-conditioning condensate piping smaller than NPS 1.25, (DN 30) copper Type L or M is permitted. Fittings: Solder joint, cast brass ANSI B16.18, or wrought copper ANSI B16.22.
 2. Pipe gaskets: 0 ring round rubber gaskets meeting the requirements of ASTM C 361.
- F. Type I: PVC DWV pipe and fittings:
1. Pipe: PVC, Schedule 40, ASTM D 1785.
 2. Fittings: PVC, DWV, ASTM D 2665.
 3. Solvent cement: PVC, ASTM D 2564.

2.22 STORM PIPING FITTINGS

- A. Leader shoes: Cast-iron, conforming to downspouts shown on architectural and mechanical drawings, equal to Neenah Foundry Company Catalog No. R-4924 through R-4928.
- B. Roof drain outlet: Equal to Zurn Z-199 downspout nozzle, flanged spout designed to direct roof overflow away from building.
1. Materials: Bronze, polished, with stainless-steel screen.
 2. Size: Noted on drawings.

PART 3 - EXECUTION

3.05 PREPARATION

- A. Connect piping to stubs as shown on the drawings. Check elevations of these connection points before installing new work.

3.20 INSTALLATION, GENERAL

- A. Use suitable tools and appliances for the safe and convenient handling and laying of pipe. Examine each section of pipe for defects. Do not lay any piece that is known to be defective. If any defective piece should be discovered after having been laid, remove and replace it at no change to the contract price.

- B. Install piping in accordance with the Pipe Installation Schedule at the end of this section, as indicated on the drawings, and in accordance with Section 22 0500, Common Work Results for Plumbing. Materials and work shall conform to local plumbing codes and health department regulations.
- C. Thoroughly clean all pipe and fittings before installing them, and keep them clean until the acceptance of the completed work. Cap or plug ends of lines to prevent debris from entering during construction.
- D. Where piping is located above food service, food storage, or food serving areas, piping shall be either DWV copper with soldered joints, or PVC with solvent cement joints, as permitted in the pipe schedule at the end of this section.
- E. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 - 1. Join hub and spigot cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
 - 2. Join hub and spigot cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints. Fill joints with lead to a depth of at least 1 inch, and make it flush with the hub of the Pipe.
 - 3. Join no-hub (hubless), cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless piping coupling joints.
 - a. Install restraint assemblies at pipe couplings and fittings for piping NPS 5 (DN 125) and larger.
- F. Install aboveground copper tubing according to Copper Development Association, Inc. (CDA) "Copper Tube Handbook."
- G. Install aboveground PVC piping according to ASTM D 2665.
- H. Install underground PVC piping according to ASTM D 2321.
- I. Make changes in direction of storm water piping with approved sanitary fittings, Y branches, 1/8 or 1/16 bends.
- J. Seal air-conditioning condensate drain where it passes through outside wall and provide splashblock if required.
- K. Install all storm piping at a 2 percent minimum downward slope in the direction of flow unless otherwise indicated.

3.21 RESTRICTIONS ON LOCATIONS

- A. Cast-iron hub and spigot piping with lead joints (Type A), and cast-iron, no-hub piping (Type C) are not permitted over food preparation, storage, serving, or dining areas.
- B. Plastic piping above ground (Type I):
 - 1. Is not allowed in HVAC ceiling plenums or shafts used to convey building air distribution.
 - 2. Requires special protection designed for plastic piping penetrations where they occur in fire-rated assemblies or floors.

3.25 INSTALLING STORM PIPING

- A. Install roof overflow piping extending 3.5 to 4 inches (75 to 100 mm) above roof. Flash as required for plumbing vents.
- B. Install leader shoes complete with cleanout, as indicated on drawings.
- C. Install roof overflow spout on each roof overflow drain outlet.
 - 1. Locations: Shown on drawings, no less than 12 inches (305 mm) above finished grade.
 - 2. Coordinate installation with wall construction and wall finish application materials, as applicable.

3.90 SCHEDULES

STORM PIPE INSTALLATION SCHEDULE					
Contractor has option where more than one x appears on a line					
MATERIAL TYPE					
USE	A	B	C	D	I
Storm, exterior	X	X			X
Storm, below slab on earth	X	X			X
Storm, concealed within walls or partitions	X		X	X	X
Storm, ceiling space	X		X	X	X
Storm, interior exposed	X		X		X
Backflow preventer discharge drain piping	X		X		
Air conditioning condensate, interior			X	X	
Air conditioning condensate, exterior					X
Miscellaneous drains from equipment			X	X	

ALL OF THE ABOVE SUBJECT TO LOCAL PLUMBING CODE AND HEALTH DEPARTMENT REQUIREMENTS

MATERIAL TYPES (Refer to Part 2 - Products)

A - Cast iron hub & spigot, lead joint

B - Cast iron hub & spigot, rubber joint
C - Cast iron no hub
D - Copper DWV
I - Plastic DWV

END OF SECTION 221413

SECTION 221423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Drains and cleanouts.
- B. Flashing material.

1.14 RELATED SECTIONS

- A. Piping: Section 221413.
- B. Curbs and flashings: Section 220506.
- C. Insulation: Section 220719.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Product data: Each specialty device or equipment, with installation instructions.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. General: Model numbers are provided in the articles below to set a standard for materials, quality of construction, options and details, and performance. Provide named products, or equal products by the acceptable manufacturers listed.
- B. Drains and cleanouts:
 - 1. Josam Company
 - 2. Jay R. Smith Manufacturing Company
 - 3. MIFAB, Inc.
 - 4. Wade
 - 5. Watts Drainage
 - 6. Zurn Plumbing Products

2.21 ROOF DRAINS

- A. Equal to Zurn ZA-100 RC.
- B. Include flashing clamp devices, roof sump receiver, and deck clamps. Where drains with extensions are required, the extension shall be suitable for the thickness of the insulation. Dome strainers: aluminum, removable, lockable in place and vandalproof.
- C. Scupper drain: Equal to Zurn Z-187, size 8 by 12 inches (203 by 305 mm).
- D. Lead for flashing roof drain: 4-lb (1.55-mm-thick) sheet.

2.23 FLEXIBLE FLASHING

- A. Flexible polyvinyl chloride sheet, waterproof and impermeable to water vapor, unreinforced, minimum 56 mils thick, recommended for use in concealed locations only.
- B. Shows no physical deterioration when tested in accordance with ASTM D 822 for at least 400 hours.
- C. Shows no cracking or flaking when, at -20 degrees F (-6.5 degrees C), it is bent 180 degrees over a 1/32-inch (0.8-mm) mandrel and back 360 degrees over the same mandrel in the opposite direction.
- D. Has no less than 1000 lbs per sq. in. (6900 kPa) tensile strength and no more than 7 percent tension set at 50 percent elongation, when tested in accordance with ASTM D 412.
- E. Products which meet this specification include but are not limited to:
 - 1. Advanced Building Products "Moistseal"
 - 2. Afco Products Company "Vi-Seal"
 - 3. York Manufacturing, Inc. "Wascoseal"

2.24 CLEANOUTS

- A. Cleanouts: Equal to following Zurn Catalog numbers. Those installed in slab on grade and in slab above crawl spaces do not require membrane flashing device. All others shall have flashing devices.
- B. In vertical storm lines:
 - 1. Exposed piping: Z-1445 with bronze cleanout plug.
 - 2. Concealed piping: ZN-1446-BP with bronze cleanout plug.
 - 3. Concealed piping where more than 8 inches (205 mm) back from finished wall line: Install a sanitary 90 degrees long turn Y fitting with bronze cleanout plug extended out to finish 1 inch (25 mm) behind finished wall. Provide with Z-1460-9x9 cover plate (access panel) with vandalproof screws.
- C. In underfloor storm lines: (See Floor Finish Schedule) All units complete with bronze plug.
 - 1. In storage areas with plain or painted concrete floors: ZB-1400.
 - 2. In exposed areas with plain or painted concrete floors: ZN-1400.
 - 3. In resilient tile floors: ZN-1400-TX.
 - 4. In ceramic tile floors: ZN-1400-T.
 - 5. In carpeted floors: ZN-1400-CM.
 - 6. In terrazzo floors: ZN-1400-DC.
- D. Outside cleanouts shall be ZN-1400-HD with vandalproof screws.

PART 3 - EXECUTION

3.21 INSTALLING ROOF DRAINS

- A. The first fitting below the roof drain shall be a T with cleanout plug, except over food preparation and serving areas.

- B. Set roof drains to fit pitch of roof.
- C. Sheet lead gaskets shall extend 12 inches (305 mm) beyond outer edge of roof drains and shall be secured with the flashing clamp.
- D. Flashing clamp ring shall be embedded into the roofing and made watertight.
- E. Ascertain that weep holes into drainage pans are open.

3.23 INSTALLING CLEANOUTS

- A. Install cleanouts at base of each vertical storm water, soil, waste, and vent stack, in the vertical piping.
- B. Cleanouts shall be the same size as the pipe into which they are installed, except no cleanout shall be larger than NPS 4 (DN 100).
- C. Install cleanouts in horizontal piping where indicated on drawings. Where cleanouts occur directly below a floor, the cleanout shall terminate with top flush with floor. Provide for the floor finish to be installed on the cleanout cover, and separated from surrounding material. Install carpet markers after carpet installation is completed. Install ceramic tile and terrazzo per manufacturer's instructions.
- D. Where cleanouts are over occupied areas, flash them with flashing specified in this section, single piece for each cleanout, 30 by 30 inches with opening cut in center to suit clamping device of cleanout. Adhere flashing to substrate with adhesive and secure to clamping device of cleanout.
- E. Cleanouts on exterior lines: Extend up flush with finish grade and support in a concrete pad, 18 by 18 inches (460 by 460 mm), 8 inches (205 mm) thick, reinforced with 6 by 6-inch (50 by 50-mm) No. 6 wire mesh.

END OF SECTION 221423

SECTION 221429 - SUMP PUMPS

PART 1 - GENERAL

1.11 WORK INCLUDED

- A. Elevator shaft sump pump system.

1.14 RELATED SECTIONS

- A. Motors: Section 220513.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Product data: Include certified performance curves and rated capacities of selected models; shipping, installed, and operating weights; furnished specialties; and accessories for each type and size of pump specified. Indicate pumps operating point on curves.
- C. Shop drawings: Show layout and connections for pumps. Include setting drawings with templates, directions for installation of foundation and anchor bolts, and other anchorages.
 - 1. Wiring diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.
- D. Maintenance data: For each pump specified, to include in maintenance manuals specified in Division 01 and Section 220101.

1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 220500, Common Work Results for Plumbing.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Specified units are the basis for design of the project. The following listed manufacturers also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article "Product Options" in Section 220101, and submit shop drawings as specified in article 1.30 above.
- B. Elevator shaft submersible sump pump systems:
 - 1. Stancor, Inc.
 - 2. Barnes, Crane Pumps and Systems
 - 3. Zoeller Co.

2.22 ELEVATOR SHAFT SUBMERSIBLE SUMP PUMP SYSTEM

- A. Basis-of-design product: Subject to compliance with requirements, provide Stancor "Oil Minder" or comparable product manufactured by other listed manufacturer.

- B. Packaged system: Submersible elevator pit system, UL 508 controller and UL 778 pump, listed and tested for elevator shaft service for automatic pumping of elevator shafts in accordance with ASME A17.1 and approved by the authority having jurisdiction.
 - 1. Components:
 - a. Liquid level switches mounted as indicated on drawings: Detect liquid levels (Pump On level and High Water Alarm level).
 - b. Sensor: Detects the presence or absence of oil.
 - c. Control system in wall-mounted NEMA 250 Type 4X enclosure.
 - d. Audible local alarm with manual reset and connections for remote alarm annunciation.
- C. Sump pump: Stancor SE100, heavy-duty, single mechanical seal, capacities and current characteristics indicated on drawings, factory-assembled and -tested, submersible, freestanding unit, rated for continuous operation.
 - 1. Minimum NPS 2 (DN 50) discharge connection with shutoff valve and check valve.
 - 2. Impeller: Cast iron or thermoplastic.
 - 3. Housing: Cast iron or stainless steel.
 - 4. Exposed parts: Stainless steel, bronze, rubber, PTFE, or high-impact molded plastic.
 - 5. Motor: Capacitor start, built-in thermal overload and lightning protection.
- D. Operation: Liquid level switches and oil sensor act in concert to automatically remove water from the sump pit while ensuring that no oil or similar substance is pumped.
 - 1. When switch indicates the Pump On level, and the oil sensor does not indicate the presence of oil, the switch shall initiate pumping until either the Pump Off level is reached or the sensor senses oil.
 - 2. When switch indicates the Pump On level, but the sensor indicates oil, pump shall shutoff and the audible alarm shall sound and alarm condition shall be annunciated.
 - 3. When switch indicates the High Water alarm level, the audible alarm condition shall be annunciated.
 - 4. Alarm condition shall require manual silencing and reset.

2.27 SUMP PUMP PIT

- A. Concrete pit as detailed on structural drawings.
- B. Pit: 24 by 24 inch (610 by 610 mm) by 24 inches (610 mm) deep.
- C. Sump pit grate: Equal to Neenah R-4826-A, heavy-duty bar grate, designed for use with concrete pit.

PART 3 – EXECUTION

3.21 INSTALLING SUMP PUMP PIT

- A. Coordinate construction of concrete pit with installation of cover. Set frame so that cover will be flush with floor.

3.22 INSTALLING SUMP PUMP

- A. Provide stop valve and spring loaded check valve in discharge from each pump.
- B. Install pump and connect to drainage piping.
- C. Set the alarm to sound if water in pit rises above the high water (pump start) level.
- D. Connect wiring between controls, pump, and remote control panel.

3.70 ADJUST AND CLEAN

- A. Set pump controls for specified operation.
- B. Before starting, perform preventive maintenance:
 - 1. Lubricate bearings.
 - 2. Disconnect couplings and inspect motors for proper direction of rotation.
 - 3. Verify that each pump rotates freely by hand. If it is bound or drags, determine the cause and correct it.
 - 4. Verify that pump controls are correct for the application.

3.80 STARTUP

- A. Start motors.
- B. Open discharge valves only.
- C. Check general mechanical operations of systems and motors.

END OF SECTION 221429

SECTION 223400 - FUEL-FIRED DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Gas-fired water heaters.

1.2 RELATED SECTIONS

- A. Equipment Foundation: Section 220529.
- B. Expansion tanks: Section 220509.
- C. Controls: Section 230901 through 230923.

1.3 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. Product data: Each type and size water heater. Include nominal capacity and pressure rating; shipping, installed, and operating weights; and specialties and accessories furnished for this project. Indicate dimensions, wall thicknesses, required clearances, method of assembly, and piping connections.
 - 1. Certification that fittings comply with NSF/ANSI 61 and NSF/ANSI 372.
- C. Include product data which verifies compliance with the energy performance requirements of ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
- D. Include operation and maintenance instructions and parts list for each type of water heater.

1.4 QUALITY ASSURANCE

- A. Each water heater shall meet the energy performance requirements of ASHRAE 90.1.
- B. Electrical components, devices, and accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. ANSI compliance: Provide gas water heaters that comply with ANSI standards for gas water heaters and related products and that bear AGA certification label.
- D. ASME compliance: Fabricate and label water heater, hot-water storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 01.
- E. UL label and local testing (if required): As specified in Section 220500, Common Work Results for Plumbing.
- F. Potable water system components intended to dispense water for human consumption, including pipe and joining materials, shall comply with the following:

1. A weighted average lead content of not more than 0.25 percent as determined by NSF/ANSI 372.
2. NSF/ANSI 61.

G. Acceptance product marking: NSF®-61 and NSF®-372 (or NSF®-61-G) or other accepted certifier marks demonstrating third party certification with these requirements.

H. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.

1.5 WARRANTY

A. In addition to the general project warranty, provide manufacturer's standard limited warranty.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Gas-fired storage water heaters:

1. A.O. Smith Corporation
2. PVI Industries, LLC
3. Rheem
4. Richmond Engineering Company
5. Ruud
6. State Water Heater

2.4 COMMERCIAL, STORAGE, HIGH-EFFICIENCY CONDENSING GAS WATER HEATER

A. Provide unit of size and capacity shown on the drawings. Unit shall be equal to CONQUEST manufactured by PVI Industries, LLC.

B. Unit construction:

1. Gas-fired water heaters will be of the BTU input(s) and storage capacity indicated on the drawings.
2. The water heater shall be vertical fire tube, constructed and stamped in accordance with Section IV, Part HLW of the ASME code. Water heater shall be National Board Registered for a working pressure of 150 psi and pressure tested at 1-1/2 times working pressure.
3. Water heater shall be a single-pass, down-fired, spiraled fire tube design contained within an integral storage tank.
4. Tank, combustion chamber and fire tubes shall be unlined.
5. Tank, combustion chamber and fire tubes to be constructed from phase-balanced austenitic and ferritic duplex steel with a chemical structure containing a minimum of 21 percent chromium. The material shall be tested and certified to pass stress chloride cracking test protocols as defined in ISO 3651-2 and ASTM G123 – 00(2005).
6. Waterside surfaces shall be welded internally.
7. All internal and external tank surfaces shall undergo full immersion passivation and pickling processing to meet critical temperature, duration and chemical concentration controls required to complete corrosion resistance restoration of pressure vessel surfaces.
8. Materials shall meet ASME Section II material requirements and be accepted by NSF 61 for municipal potable water systems.

9. ASME-rated temperature/pressure relief valve.
10. All water contacting tank surfaces will be non-porous and exhibit 0 percent water absorption.
11. All tank connections/fittings will be non-ferrous or stainless steel.
12. Finished vessel shall not require sacrificial anode rods.
13. Combustion shall be provided by a premix, fan-assisted surface burner with a gas train meeting UL, ANSI and FM standards for the input specified.
14. Burner shall be stainless steel.
15. Gas train components shall be capable of self-proportionating gas and air to maintain optimum combustion in response to varying vent pressures.
16. Burner will be fixed input.
17. Burner NOx emissions shall be less than 20 ppm when corrected to 3 percent oxygen.
18. Water heater shall be a category IV, condensing appliance and vent through Schedule 40 PVC. Water heater shall satisfy requirements for sealed combustion.
19. Water heater shall be ETL listed for connection to a concentric vent termination.
20. When tested to the ANSI Z21.10.3 standard, water heaters with inputs from 400,000 to 600,000 BTU shall operate at 96 percent thermal efficiency at full fire rate.
21. Connection for a building return circulation line shall be made to a dedicated hot return fitting at the center of the tank.

C. Insulation:

1. Fiberglass, limiting heat loss to no more than 14 BTU per hour per square foot of tank surface in ambient temperature of 65 degrees F.
2. Flame spread not to exceed 25 and fuel contribution not to exceed 50 when tested in accordance with ASTM E 84.

D. Exterior jacket: Polyethylene.

E. Vents: Schedule 40 PVC direct vent intake and exhaust terminating separately outside building.

2.9 WATER HEATER SPECIALTIES

- A. Vacuum relief valve: Designed for vacuum relief in hot water tanks and heaters, ANSI Z21.22, brass body, high-heat-resisting disk, equal to Watts No. LFN36.
1. Working pressure: At least 200 psi.
 2. Temperature rating: At least 250 degrees F.
 3. Operation: Closes under pressure and opens on vacuum of not more than 0.5 inches of mercury.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Provide each heater with ASME rated temperature and pressure relief valves.

3.2 INSTALLING DOMESTIC WATER HEATER

- A. Set heater on an equipment foundation (housekeeping pad). Plug all unused tappings.
- B. Install level and plumb, according to drawings and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so that controls and devices are accessible.

- C. Anchor water heaters to substrate.
- D. Install and connect water heaters in accordance with applicable code for fuel-fired water heaters.
- E. Install temperature and pressure relief valves. Extend relief valve outlet with water piping in continuous downward pitch and discharge to closest floor drain.
- F. Install vacuum relief valves.

3.3 MANUFACTURER'S FIELD SERVICE

- A. Provide manufacturer's startup and adjustment for gas-fired water heater(s).

3.4 OPERATING INSTRUCTIONS

- A. As specified in Section 220500, provide operating instructions.
- B. Provide at least 2 hours of additional instruction time for the equipment specified in this section.

END OF SECTION 223400

SECTION 224200 - INSTITUTIONAL PLUMBING FIXTURES

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Institutional grade plumbing fixtures and trim, faucets, other fittings, and related components.

1.14 RELATED SECTIONS

- A. Piping: Sections 221116, 221316, and 221413.
- B. Valves: Section 220523.
- C. Plumbing specialties: Section 221119.
- D. Sections specifying requirements for LEED rating are specified in Division 01.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 220101.
- B. LEED submittals:
 - 1. Product data for prerequisite WE 1: Documentation indicating flow and water consumption requirements.
- C. Product data: For each type of plumbing fixture specified, including fixture and trim, fittings, accessories, appliances, appurtenances, equipment, supports, construction details, dimensions of components, and finishes.
 - 1. Certification that products comply with NSF/ANSI 61 and NSF/ANSI 372.
- D. Shop drawings:
 - 1. Provide a schedule of fixtures and trim proposed for use, in the same order as the lists in the specification.
 - 2. Wiring diagrams for field-installed wiring of electrically operated units.
- E. LEED Submittals: For water closets and urinals, documentation indicating flush rate in gallons per flush (GPF); for faucets, showerheads and spray rinse valves, documentation indicating flow rate in gallons per minute (GPM).

1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 220500, Common Work Results for Plumbing.
- B. Comply with requirements for LEED certification specified in Division 01.
- C. Fixtures shall be of the best commercial grade of their respective kinds, free from flaws, cracks, craze or other imperfections, complete with fittings and connections. Residential grade fixtures shall not be acceptable. Fixtures manufactured by acceptable manufacturers are acceptable provided they are equal and similar to those specified.

- D. Fixtures and trim where required to be accessible to disabled people, identified in this section as “for disabled,” shall comply with requirements of the Americans with Disabilities Act (ADA) Regulations, as applicable to each type of fixture or its use.
 - 1. Trim must meet requirements for force of operation at water pressures up to 80 psi.
 - 2. Water closet and urinal models must be selected and installed so that flush controls will be on the fixture’s open side.
- E. Potable water system components intended to dispense water for human consumption, including pipe and joining materials, shall comply with the following:
 - 1. A weighted average lead content of not more than 0.25 percent as determined by NSF/ANSI 372.
 - 2. NSF/ANSI 61.
- F. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design products: Subject to compliance with requirements, provide specified or scheduled products or comparable product by one of the following.
 - 1. Fixtures:
 - a. American Standard
 - b. Bradley Corporation
 - c. Commercial Enameling Co.
 - d. Crane Co.
 - e. Eljer
 - f. Elkay Manufacturing Co.
 - g. Fiat Products
 - h. Guy Gray; IPS Corporation
 - i. Just Co.
 - j. Kohler Co.
 - k. E.L. Mustee & Sons, Inc.
 - l. Zurn Plumbing Products
 - 2. Emergency fixtures:
 - a. Bradley Corporation
 - b. Encon Safety Products
 - c. Guardian Equipment
 - d. Haws Corp.
 - e. Speakman Co.
 - 3. Faucets:
 - a. Chicago Faucet Co.
 - b. Speakman Co.

- c. T & S Brass and Bronze Works, Inc.
- 4. Supplies, traps, and miscellaneous trim:
 - a. Brass-Craft Manufacturing Co.
 - b. Chicago Faucet Co.
 - c. Engineered Brass Co.
 - d. McGuire Manufacturing Co.
 - e. T & S Brass and Bronze Works, Inc.
- 5. Toilet seats:
 - a. Bemis
 - b. Beneke Corp.
 - c. Church Seats
 - d. Olsonite Co.
 - e. Sperzel Co.
- 6. Flush valves:
 - a. Delaney Flush Valves
 - b. Sloan Valve Co.
 - c. Zurn Plumbing Products
- 7. Water coolers:
 - a. Eljer Manufacturing, Co.
 - b. Elkay Manufacturing Company
 - c. Halsey Taylor
 - d. Haws Corp.
 - e. Oasis Water Coolers
 - f. Sunroc Corporation
- 8. Fixture supports and carriers:
 - a. Josam Mfg. Co.
 - b. J.R. Smith
 - c. Zurn Plumbing Products

2.20 FIXTURES

- A. Model numbers are intended to describe complete fixtures. Furnish all parts and fittings regularly required such as tailpieces for lavatory faucets, escutcheons, and appurtenances, including low-voltage devices and wiring for fixtures which require them to operate.
- B. Fixtures shall be white except where another color is specified for a particular fixture.
- C. Water closet and urinal models specified or noted to be accessible in accordance with ADA requirements: Select models such that flush controls will be on the fixture's open side when fixtures are installed.

2.31 WATER CLOSETS

- A. F-1 water closet: Kohler "Wellcomme" K-4350, dual flush.

1. Material: Vitreous china.
2. Bowl type: Elongated, siphon jet, NPS 1.5 (DN 40) top spud.
3. Passageway: 2.25 inches (57 mm).
4. Mounting: Floor-mounted. 14.75 inches (375 mm) rim to floor, use solid brass closet bolts.
5. Consumption: 1.1 gallons (4.2 L) and 1.6 gallons (6L) for dual flush cycles.
6. Trim:
 - a. Seat: No. 1
 - b. Flush valve: No. 14
 - c. Bolt caps: Two, No. 115

B. F-1A water closet, student disabled: Kohler "Wellcomme" K-4350, dual flush.

1. Material: Vitreous china.
2. Bowl type: Elongated, siphon jet, NPS 1.5 (DN 40) top spud.
3. Passageway: 2.25 inches (57 mm).
4. Mounting: Floor-mounted. 14.75 inches (375 mm) rim to floor, 15.75 inches (400 mm) top of seat. Use solid brass closet bolts.
5. Consumption: 1.1 gallon (4.2 L) and 1.6 gallons (6L) for dual flush cycles.
6. Trim:
 - a. Seat: No. 1
 - b. Flush valve: No. 14
 - c. Bolt caps: Two, No. 115

C. F-1B water closet for disabled: Kohler "Highcliff" K-4368, dual flush.

1. Material: Vitreous china.
2. Bowl type: Elongated, siphon jet, NPS 1.5 (DN 40) top spud.
3. Passageway: 2.25 inches (57 mm).
4. Mounting: Floor-mounted, 17.5 inches (445 mm) rim to floor, 18.5 inches (545 mm) top of seat. Use solid brass closet bolts..
5. Consumption: 1.1 gallons (4.2 L) and 1.6 gallons (6L) for dual flush cycles.
6. Trim:
 - a. Seat: No. 1
 - b. Flush valve: No. 14
 - c. Bolt caps: Two, No. 115

2.32 URINALS

A. F-2 urinal: Kohler HEU System "Bardon" K-4991-ET.

1. Material: Vitreous china.
2. Urinal type: Washdown action, NPS 3/4 (DN 20) top spud.
3. Mounting and outlet: Wall-mounted, outlet threaded, NPS 2 (DN 50).
4. Rim height: 17 inches (532 mm), above floor.
5. Consumption: No more than 1 pint or 0.125 gallon (0.47 L) per flushing cycle.
6. Trim:
 - a. Flush valve: No. 16.

2.33 LAVATORIES

- A. F-3 wash station: Bradley MF 2949 "Terreon Wall Hung-Quadra Fount"
1. Material: "Terreon" solid surface material composed of polyester resin certified to meet ANSI Z124.3, Z124, and ANSI/1 CPA SS-1-2001.
 2. Color: Lannon.
 3. Pedestal frame and access panel: Type 304 stainless steel.
 4. Sprayheads: Four sprayheads, molded as integral part of bowl.
 5. Infrared control: Each sprayhead shall be controlled by separate solenoid valves. Solenoid valves shall be 24-V-60Hz with 0.375 inch NPT connection.
 6. Thermostatic water temperature controller (ASSE 1070).
 7. Low-voltage transformer: Class II UL listed, 110/24 VAC plug-in transformer.
 8. Mounting: Wall-mounted, 34 inches (864 mm) rim to floor. Include cast-iron carrier fitting to connect to support specified in the article "Support for Wall-Mounted Fixtures" below.
 9. Trim:
 - a. Trap: No. 104
- B. F-3A lavatory, student disabled: Kohler "Hudson" K-2868
1. Material: Cast iron with acid-resisting enamel.
 2. Lavatory type: Rectangular, front overflow, 8-inch (203-mm) faucet centers.
 3. Dimensions: 20 by 18 inches (508 by 457 mm).
 4. Mounting: Wall-mounted, 31 inches (787 mm) rim to floor. Include cast-iron carrier fitting to connect to support specified in the article "Support for Wall-Mounted Fixtures" below.
 5. Trim:
 - a. Faucet: No. 41
 - b. Supply: Two No. 25
 - c. Nipple: Two No. 62
 - d. Drain: No. 80
 - e. Trap: No. 106
 - f. Lavatory insulation kit: No. 122
 - g. Thermostatic mixing valve: No. 61
- C. F-3B lavatory adult disabled: Kohler "Hudson" K-2868.
1. Material: Cast iron with acid-resisting enamel.
 2. Lavatory type: Rectangular, front overflow, 8-inch (203-mm) faucet centers.
 3. Dimensions: 20 by 18 inches (508 by 457 mm).
 4. Mounting: Wall-mounted, 34 inches (876 mm) rim to floor. Include cast-iron carrier fitting to connect to support specified in the article "Support for Wall-Mounted Fixtures" below.
 5. Trim:
 - a. Faucet: No. 41
 - b. Supply: Two No. 25
 - c. Nipple: Two No. 62
 - d. Drain: No. 80
 - e. Trap: No. 106
 - f. Lavatory insulation kit: No. 122
 - g. Thermostatic mixing valve: No. 61

2.34 SERVICE SINKS

A. F-4 sink, mop: Fiat Model MSB-3624.

1. Material: Molded stone, white with black accents.
2. Sink type: One-piece mop service basin with integrally molded shelf 10.5 inches (267 mm) wide.
3. Dimensions: 36 by 24 inches (914 by 610 mm), 10 inches (254 mm) deep. Both sides shall be 10 inches (254 mm) high with one-inch (25-mm) -wide shoulders.
4. Mounting: Floor-mounted.
5. Accessories: Drain body, No. 302 stainless steel, with combination dome strainer and lint basket, designed for an NPS 3 (DN 80) connection.
6. Trim:
 - a. Faucet: No. 47.
 - b. Mop hanger: No. 121.

2.35 SINKS

A. F-5 classroom sink for student disabled: Elkay Model LRADQ 2521-5.5.

1. Material: Type 304 stainless steel, 18-gage, coated on the underside with sound deadening material.
2. Sink type: Single-compartment, with seamless radius-coved corners, two hole ledge for faucet, 8-inch (203-mm) centers, rear center 3.5-inches (89 mm) drain outlet.
3. Overall dimensions: 25 by 21 inches (635 by 540 mm), by 5.5 inches (144 mm) deep.
4. Bowl dimensions: 21 by 15.75 inches (533 by 400 mm).
5. Mounting: In countertop specified in Division 06.
6. Trim:
 - a. Faucet: No. 200
 - b. Supply: Two No. 25
 - c. Nipple: Two No. 62
 - d. Drain: No. 85
 - e. Trap: No. 104
 - f. Thermostatic mixing valve: No. 61

B. F-5A classroom sink for student disabled: Elkay Model LRADQ2521-5.5.

1. Material: Type 304 stainless steel, 18-gage, coated on the underside with sound deadening material.
2. Sink type: Single-compartment, with seamless radius-coved corners, two hole ledge for faucet, 8-inch (203-mm) centers, rear center, 3.5-inches (89 mm) drain outlet.
3. Overall dimensions: 25 by 21 inches (635 by 540 mm) by 5.5 inches (144 mm) deep.
4. Bowl dimensions: 21 by 15.75 inches (533 by 400 mm).
5. Mounting: In countertop specified in Division 06.
6. Trim:
 - a. Faucet: No. 200
 - b. Supply: Two No. 25
 - c. Nipple: Two No. 62
 - d. Drain: No. 85
 - e. Trap: No. 104
 - f. Thermostatic mixing valve: No. 61

C. F-5B sink: Elkay Model LRAD-2219.6.5

1. Material: Type 304 stainless steel, 18-gage, coated on the underside with sound deadening material, satin finish with polished rim.
2. Sink type: Single-compartment, with seamless radius-coved corners, 3-hole ledge for faucet, 8-inch (203-mm) centers, rear center, 3.5 inches (89 mm) drain outlet.
3. Overall dimensions: 22 by 19 inches (559 by 483 mm) by 6.5 inches (165 mm) deep.
4. Bowl dimensions: 18 by 14 inches (457 by 356 mm)
5. Mounting: In countertop specified in Division 06.
6. Trim:
 - a. Faucet: No. 200
 - b. Supply: Two No. 25
 - c. Nipple: Two No. 62
 - d. Drain: No. 85
 - e. Trap: No. 104
 - f. Thermostatic mixing valve: No. 61

D. F-5C sink art room: Elkay DLR2521 10 PD

1. Material: Stainless steel with sound deadening material on underside, Type 304, 18-gage, nickel bearing stainless steel finish with polished rim.
2. Sink type: Single-compartment, self-rimming, two-hole ledge for faucet, 8-inch (203-mm) centers, punched to receive the faucet specified in this trim. Center 3.5 inches (89 mm) drain outlet.
3. Overall dimensions: 25 by 21 1/4 inches (635 by 540 mm), 10 inches (254 mm) deep.
4. Bowl dimensions: 21 by 15 3/4" inches (533 by 400 mm).
5. Mounting: In countertop specified in Division 06.
6. Trim:
 - a. Faucet: No. 201
 - b. Supply: Two No. 25
 - c. Nipple: Two No. 62
 - d. Drain: No. 85
 - e. Solids interceptor: No. 110
 - f. Thermostatic mixing valve: No. 61

E. F-5D sink for student disabled, art room: Elkay LRAD-2219-5.5

1. Material: Stainless steel with sound deadening material on underside, Type 304, 18-gage, nickel bearing stainless steel finish with polished rim.
2. Sink type: Single-compartment, self-rimming, two-hole ledge for faucet, 8-inch (203-mm) centers. Rear off-center 3.5 inches (89 mm) drain outlet.
3. Overall dimensions: 22 by 19 inches (559 by 483 mm), 6.5 inches (165 mm) deep.
4. Bowl dimensions: 18 by 14 inches (457 by 356 mm).
5. Mounting: In countertop specified in Division 06.
6. Trim:
 - a. Faucet: No. 200
 - b. Supply: Two No. 25
 - c. Nipple: Two No. 62
 - d. Drain: No. 85
 - e. Solids interceptor: No. 110

- f. Thermostatic mixing valve: No. 61

2.36 WATER COOLERS

- A. F-6 bi-level (student disabled) water cooler: Oasis Model PG8EBFSL, barrier free, surface wall mounted unit with bottle filling station mounted above ADA side.
1. Water cooler type: Refrigeration circuit with hermetically sealed compressor with air-cooled condenser, utilizing refrigerant R-134a. Unit shall be UL listed and comply with ARI 1010 Testing, Operating and Rating requirements.
 2. Capacity: To cool 8 gallons (30 L) per hour with inlet water 80 degrees F and room temperature at 90 degrees F. Unit shall have a built-in strainer.
 3. Lead: Unit shall contain no lead. This requirement exceeds the standard designation of "lead free." Unit shall be NSF/ANSI Standard 61 and 372 certified.
 4. Construction: Front and side mounted push pads, stainless-steel satin finish basin, heavy-duty galvanized-steel frame supporting powder-coated galvanized exterior panels.
 5. Bubbler: Flexible hooded rubber bubbler with non-squirt feature.
 6. Mounting: Bubblers shall be 36 inches and 30 inches (914 mm and 762 mm) above finished floor.
 7. Bottle filling station with brushed stainless-steel cabinet and hand-free activation. Install above ADA side.
 8. Electrical: 115 volt duplex receptacle connected to a minimum 20-amp ground fault circuit interrupting (GFCI) device to meet UL requirements.
 9. Fittings and accessories:
 - a. Supply: With shutoff valve and strainer furnished by manufacturer.
 - b. Trap: Trim No. 106.

2.37 SHOWERS

- A. F-7 shower, adult, for disabled: Bradley Type HN250 shower panel, stainless-steel, with plumbing access panel and piping shroud extending to ceiling. Wall-mounted on brackets provided with unit.
1. Enclosure and receptor: Not part of specified unit.
 2. Mounting height of shower head: 72 inches
 3. Fittings and accessories:
 - a. Shower head: Bradley Model SX fixed direction type, with Equa-Flo HD pressure balance mixing valve with Integral stops, and diverter valve with lever handle and Model G, 1.5 gpm flow control.
 - b. Hand shower: Hand-held spray with 59-inch stainless-steel flexible hose and post style mounting bracket to hold spray on panel. Elevated inline backflow preventer with quick disconnect for flexible hose.
 - c. Accessories: Recessed cake soap tray, panel-mounted grab bar meeting accessibility requirements, folding shower seat with Naugahyde cover, shower curtain rod with vinyl curtain and hooks.

2.38 OUTLET BOXES FOR ICE MAKER

- A. F-8 Ice maker supply box: Guy Gray Model SSIB 1 AB.
1. Material: 20-gauge, Type 304 stainless-steel box and cover.
 2. Mounting: Flush mount in partition 42 inches (1066 mm) above floor.

3. Valve: NPS 0.5 (DN 15) supply valve. NPS 0.25 (DN 8) compression outlet.
4. Box dimensions: 8.25 by 6 inches (210 by 152 mm) by 3.5 inches (90 mm).
5. Trim cover dimensions: 10.875 by 8.375 inches (276 by 212 mm).
6. Trim:

- a. Vacuum breakers: No. 67

2.65 TRIM

- A. Exposed trim shall be chrome-plated.
- B. Exposed trim shall be vandalproof.
- C. Faucets: Equal to the named model shall mean similar in appearance, function, and design. Internal parts are not required to be interchangeable.
- D. Flush valves shall be provided with vacuum breakers.
- E. Trim numbers listed in the fixture descriptions above represent the descriptions in the article "Trim Schedule" at the end of the section.

2.70 SUPPORTS FOR WALL-MOUNTED FIXTURES

- A. Lavatories mounted on shafts or partitions where there is no floor on the opposite side: Equal to Zurn Z-1259 plate carriers.
 1. Single lavatory: The plate carrier shall have a backup plate of 10-gage steel, at least 6 inches (152 mm) high by 38 inches (965 mm) long.
 2. Battery-mounted lavatories: The 10-gage backup plate shall be continuous for full length of battery of fixtures, with the carrier plates properly spaced and welded to the backup plate.
- B. For lavatories mounted on partitions where there is a floor on the opposite side: Equal to Zurn Z-1224 plate carrier with legs anchored to floor.
- C. Urinals: Equal to Zurn Z-1222 chair carriers, anchored to floor.
- D. Other wall-supported fixtures: Cast-iron wall hangers securely bolted to wall.
 1. Where void spaces occur on opposite side of partition: 0.375-inch through bolts with plate washers.
 2. Where finished surfaces occur on opposite side of partition: Toggle bolts or bolts with plate washers built within the walls.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Furnish, provide rough-in for, and set fixtures to extent and number indicated on drawings. The fixtures shall be left in first class condition, properly adjusted, cleaned and ready for satisfactory operation.
 1. Where water closets and urinals are specified or noted to be accessible in accordance with ADA requirements, ensure that flush controls are installed on the fixture's open side.

2. Coordinate elevations of water closet flush valve rough-ins with rough-ins for grab bars and other wall-mounted items.

B. Protect plumbing fixtures and board them over so that they cannot be used until final acceptance of the work.

3.21 SETTING OF FIXTURES

A. In locations where fixtures are set against walls, seal crack between wall and fixture with silicon sealant.

B. Set floor outlet fixtures on floor flanges with gaskets and cement-grout them to rest firmly and evenly on floors. Water closets shall be secured with two bolts attaching to the floor flanges and the base shall be sealed to the floor using a clear silicone caulk. The fixtures shall be secured over these bolts with Trim No. 115 bolt caps.

C. Securely attach wall hung fixtures to wall using specified supports.

D. Install solids interceptor so that strainer can be removed for cleaning.

E. After installation, paint undersides of cast-iron lavatories and service sinks. Paint galvanized traps with two coats of white enamel.

F. Maximum length of risers shall be 12 inches (305 mm). Install supplies at heights as required to make connection to faucet.

3.22 MOP SINKS

A. Install basins for mop sinks as recommended by manufacturer with space between basin and wall completely filled with a waterproof silicon sealant. Provide P trap.

3.23 INSTALLATION OF FIRE-RATED OUTLET BOXES FOR ICE MAKER

A. Install box(es) in accordance with the manufacturer's recommendations.

3.90 TRIM SCHEDULE

<u>Trim No.</u>	<u>Description</u>
1	Seat: Church No. 295 SSCT white solid plastic, elongated, open front; stainless-steel hinge posts with combination self-sustaining and check hinge.
14	Flush valve: Sloan Dual-Flush No.WES-111, complete with vacuum breaker, NPS 1.5 (DN 40) top spud connection and flanges, 1.6 gallons (6 L) per flushing cycle by pushing down, and 1.1 gallons (4.2 L) per cycle by pulling up. Include cast escutcheon, vandal-resistant stop cap, and ADA-compliant handle operation.
16	Flush valve: Sloan "Royal" No. 186-0.125 manual flush valve for HEU system, complete with vacuum breaker, NPS 0.75 (DN 20) top spud connection and flanges, 0.125 gallon (0.5 L) per flushing cycle. Include cast escutcheon, vandal-resistant stop cap, and ADA-compliant handle operation.
25	Supply and stop: Chicago No. 1019-ABCP supply with 0.500-inch threaded inlet angle valve, 0.375-inch OD by 12-inch bullnose riser, chrome-plated finish, and slip wall flange.

<u>Trim No.</u>	<u>Description</u>
41	Faucet: Chicago No. 404-VE2805-665ABCP combination hot and cold metering, widespread, slow-closing, with 5-inch (127-mm) spout and vandalproof 0.5 gpm flow restrictor.
47	Faucet: Chicago No. 445-897SRCXKCP, vacuum breaker spout with ¾-inch hose thread outlet, integral stops in shank, lever handles, adjustable support arms, wall brace with adjustable rod, and pail hook.
61	Individual thermostatic mixing valve: Chicago Faucet No. 131-CABNF, ASSE 1070, brass body construction, less than 0.25 percent lead content, 0.375-inch compression inlets/outlets, integral check valves, temperature adjustment cap with lock, wall bracket, minimum flow rate 0.35 gpm, maximum flow rate 4.6 gpm, 0.375-inch compression tee inlet connection for cold water bypass.
62	Nipples: Brass Craft triple-plated polished chrome of length and size as required.
67	Backflow preventer: Watts No. LFN9C dual check vacuum breakers to prevent back-siphonage of water flow. Complies with the requirements of CSA B64.8. Brass body construction with polish chrome plating. 125 psi (8.6 bar) maximum working pressure and 33 degrees F to 140 degrees F (0.5 degrees C to 60 degrees C) temperature range. Inlet and outlet connection is NPS 0.25 (DN 6).
80	Drain: McGuire No. 155-A, non-removable open grid strainer, 1.25 by 6 inch tailpiece.
85	Drain: Elkay No. LK-18-B stainless-steel stamped drain fitting, 4.5-inch (114-mm) top with 3-inch (76-mm) grid, and 1.5-inch OD tailpiece.
104	P trap: McGuire No. 8089, 1.5 by 1.5-inch IPS outlet, cast-brass ground joint, swivel type, with cleanout, complete with NPS 1.5 cast-brass nipple and cast set-screw escutcheon.
106	P trap: McGuire No. 8090, 1.25 by 1.5 inch IPS outlet, cast-brass, ground joint, swivel type, with cleanout and complete with McGuire No. 2127, NPS 1-1/2 (DN 40) brass nipple with cast set screw escutcheon.
110	Solids interceptor drain: Zurn No. ZA-1180-CS-SS, interior and exterior acid-resistant coated, steel fabricated solids interceptor. Top access with gasketed and secured cover, removable 3/32-inch-perforated stainless-steel diffusing/intercepting screens and acid-resistant-coated steel sediment bucket.
115	Bolt caps: Chrome-plated acorn nuts, size as required.
121	Mop hanger: Fiat Products, Inc. No. 889-CG 24 inches (610 mm) long by 3 inches (76 mm) wide, 18-gage, No. 302 stainless-steel mop hanger complete with slotted matching screws for mounting.
122	Lavatory insulation kit: Truebro Lav-Guard 2" Series 102 E-Z fully molded interlocking trap assembly and angle valve assemblies. Color: white.
200	Faucet: Chicago No. 201-AGN8AE2805-5-317CP combination hot and cold water 8-inch (203 mm) center faucet with 8-inch high rise rigid/swing gooseneck spout with 120 degree

<u>Trim No.</u>	<u>Description</u>
	limited swing, No. 317 wristblade handles and E2805 JKCP, 0.5 gpm (1.9 L/M) vandal proof non-aerating spray outlet.
201	Faucet: Chicago No. 201-GN10ASWGJKABCP-E35JKABCP-317CP combination hot and cold, widespread, No. 317 wristblade handles with rim flanges, 140 degree restricted swing, 14.5 inch (368 mm) rigid/swing high rise gooseneck spout, E35JKABCP, 1.5 gpm (5.7L/M) vandalproof non-aerating spray outlet.

END OF SECTION 224200

SECTION 230100 - OPERATION AND MAINTENANCE OF HVAC SYSTEMS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Service for heating, ventilating, and air conditioning equipment required for the work as indicated on the drawings, including the items listed in "Related Sections".

1.14 RELATED SECTIONS

- A. Operating manuals: Division 01 and Section 230101.
- B. General project warranty: General Conditions.
- C. Boilers: Section 235216.
- D. Unit heaters: Section 238239.
- E. Chillers: Section 236419.
- F. Pumps: Section 232123.
- G. Air-handling units: Section 237322.
- H. Air-conditioning units: Sections 237413 and 238127.
- I. Fan-coil units: Section 238219.
- J. Energy recovery and dedicated outdoor air units: Section 237200.
- K. Variable refrigerant system: Section 238128.
- L. Condensing unit: Section 236313.

1.26 DESIGN REQUIREMENTS

- A. The products specified, scheduled, and shown on drawings are the basis of the design of this project.
- B. For requirements affecting use of optional manufacturers, or substitutions, see Division 01 and Section 230101, HVAC General Provisions, and Section 230500, Common Work Results for HVAC.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Shop drawings:
 - 1. Refrigeration service organization: Name and address of proposed agency.
 - 2. Burner startup and service organization: Name and address of proposed agency.
 - 3. Proposed service or test agreement of each type included in the project, showing conformance to specifications. Include detailed list of work to be performed at each visit.

C. Certifications:

1. Qualifications of burner startup and service agency.
2. Qualifications of refrigeration installation and service agency.
3. Each installation and service organization: A list of at least ten projects, similar to this project in type, size, and components, which has been operating satisfactorily for at least two heating and cooling seasons.
4. Include evidence of each requirement specified in article 1.41, "Qualifications," below.

D. Field test reports:

1. Burner startup reports for each burner.
2. Test and inspection reports for refrigeration equipment.
3. Besides the number specified in general submittal requirements, submit copies to the County Health Department, Division of Air Quality Control and the Owner.

1.40 QUALITY ASSURANCE

- A. Perform work in accordance with the plumbing, electrical, building, fire and safety codes of the state, county or city in which the work is performed.
- B. UL label and local testing (if required): As specified in Section 230500, Common Work Results for HVAC.
- C. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1 Energy Efficient Design of New Buildings Except Low-rise Residential Buildings.
- D. Burner operation shall meet the requirements for exhaust gases and temperature of the applicable authorities having jurisdiction.

1.41 QUALIFICATIONS OF EACH SERVICE AND MAINTENANCE AGENCY

- A. Regularly engaged in performing installation, startup, and service work for equipment and systems of the types included in this project.
- B. Located in the Baltimore/Washington, DC, metropolitan area.
- C. Staff factory-trained by the manufacturer of the equipment included in this project.
- D. Provides emergency service on call 24 hours a day.
- E. Maintains an adequate stock of manufacturer's genuine or approved parts to service this equipment.
- F. Has service contracts available, which can meet requirements specified for the equipment and systems of this project.

1.91 BURNER START-UP AND SERVICE

- A. Provide startup and service for each burner installed as part of the work, by an agency qualified as described above.

- B. Approved agency shall start, adjust, and test the complete burner system, and shall provide service as specified below during the term of the general project correction period.
- C. Check all parts of the installation applicable to the burner, and verify that fuel piping installation, wiring, control installation, and appurtenances are in accordance with the recommendations of the burner manufacturer. Upon initial start-up, operate and adjust the burner to obtain the performance specified by the burner manufacturer.
- D. Startup report shall include:
 - Fuel pressure to nozzle - inches of Hg.
 - Stack draft - inches wg, positive or negative
 - Fire box pressure - inches wg, positive or negative
 - Gross stack temperature - degrees F (maximum allowable 500 degrees F)
 - Room temperature - degrees F
 - Net stack temperature - degrees F
 - CO₂ in fire box - percent CO₂
 - CO₂ in flue gases - percent CO₂
 - Smoke reading on the Bacharach scale
 - Calculated combustion efficiency
 - 1. Provide readings and calculations for both high and low fire settings, or six progressive sets of readings and calculations for modulating firing controls.
 - 2. Test the operation of the flame safeguard control, all operating and limit controls, and the function of the low water cutoff. In the startup report, certify that these functions have been checked and that operation is satisfactory.
- E. After the system has been operating under normal occupancy conditions for at least two weeks but not more than four weeks, repeat the adjustments and tests, and prepare another report including the same information.
- F. During the first adjustment session, the Owner's maintenance personnel shall be present, and shall be instructed in the proper operation of the burner and its associated control system.
- G. Notify the Architect and representative of the County Health Department Division of Air Quality Control at least one week prior to the scheduled final start-up, so that they may arrange to have representatives present to observe the burner start-up and adjustment.

1.93 REFRIGERATION EQUIPMENT WARRANTY AND SERVICE

- A. Manufacturer's authorized and factory-trained startup and service organization will be responsible for starting, adjusting, and servicing the complete refrigeration system during the term of the correction period of this contract.
- B. Ascertain that piping installation, wiring, control installation, and appurtenances of each refrigeration unit are in accordance with the recommendations of the manufacturer. Upon initial startup, operate and adjust the unit to obtain the performance specified by the manufacturer.
- C. Special warranties shall cover the replacement of all parts and components for no less than the time of the general project correction period, starting from the date of substantial completion.
- D. Compressors shall have an additional extended parts-only warranty for a total of five years including the general correction period.

- E. Refrigerant circuits of self-contained units shall have an additional extended parts-only warranty for a total of five years including the general correction period.
- F. Supply emergency service promptly upon call during correction period with no extra charge to Owner.
- G. Maintenance in addition to repair: In addition to the repair service required during the correction period, provide maintenance by the manufacturer's authorized factory-trained local agent including routine calls by a factory trained representative, not less than one call every two months during the cooling season. The planned maintenance program shall include:
 - 1. Inspect complete refrigerant circuit for refrigerant leaks with approved halide or electronic leak detector.
 - 2. Replace defective parts and refrigerant at no addition to the contract sum.
 - 3. Tighten belts, nuts, screws, and terminal wiring connections as required.
 - 4. Clean evaporator-condenser coils as needed.
 - 5. Lubricate moving parts as needed.
 - 6. Adjust, align, and replace belts where needed.
 - 7. Check for oil or refrigerant leaks and correct as necessary.
 - 8. Check for blockage of condensate elimination system and correct as required.
 - 9. Check and record unit starting and running amperage.
 - 10. Check and record power voltage and control voltage.
 - 11. Check and record operating temperatures and pressure. (Pressure not required on hermetic circuits.)
 - 12. Check and record thermostatic expansion valve super heat.
 - 13. Check temperature and pressure controls and adjust as required.
 - 14. Check for proper operation of limit switches and safety controls.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.01 ELECTRIC WIRING FOR MOTORS, STARTERS, AND CONTROLS

- A. Furnish and install and in most cases factory-wire motor starters specified under each technical section in this division. Furnish and install under Division 26 magnetic starters not specifically specified with equipment. Unless specified otherwise, automatic control devices for equipment are furnished with the equipment.
- B. Unless explicitly specified otherwise, mount and completely wire under Division 26 all starters and automatic control devices, except those which are factory-mounted on equipment.
- C. Unless specified otherwise, motor disconnects, manual starters, pushbutton stations, and pilot lights are specified in Division 26, Electrical. Equipment specified in Division 23 shall be suitable for operation in conjunction therewith.
- D. Unless specified otherwise in a particular section, electric motors shall comply with the requirements of Section 230513.

3.59 IDENTIFICATION

- A. Identify equipment as required in Section 230500, Common Work Results for HVAC.

- B. Thermometers, gages, and control devices shall be identified.

3.61 TESTING MECHANICAL EQUIPMENT

- A. Check and adjust all heating and cooling equipment installed.
- B. Operate heating and cooling equipment and check controls including high and low limit controls.
- C. Mechanical equipment shall be proven to function properly by actual operation prior to final acceptance.

3.71 EQUIPMENT LUBRICATION

- A. Bearings of equipment shall be provided with adequate facilities for lubrication. Oiling devices shall be accessible. Lubricate bearings upon completion of work prior to startup of the equipment. Lubricants shall be as specified by equipment manufacturers.

END OF SECTION 230100

SECTION 230101 - HVAC GENERAL PROVISIONS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. General provisions and requirements for all HVAC work.

1.14 RELATED SECTIONS

- A. Requirements of this section generally supplement requirements of Division 01.
- B. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.

1.20 REFERENCES

- A. NFPA 10: Portable Fire Extinguishers.
- B. NFPA 241: Safeguarding Construction, Alteration, and Demolition Operations.

1.25 SYSTEM DESCRIPTION

- A. The full set of Contract Documents applies to work of Division 23.
- B. Visit the site and study all aspects of the project and working conditions, as required by General and Supplementary Conditions, Bidding and Contracting Requirements, Drawings, and Specifications. Verify field dimensions.
- C. The work covered in technical sections includes the furnishing of all labor, equipment and materials, and the performance of all operations pertinent to the work described.
- D. Except as required otherwise in Division 01, promptly obtain and pay for, including all necessary signatures and paperwork, all permits, fees and inspections required for work of this division by authorities having jurisdiction, including any utility connection or extension charge. No payment will be made until a copy of the permit is forwarded to the Owner.
- E. HVAC work of this project includes, as a brief general description, the following:
 - 1. Provision of air-cooled chiller, condensing boilers, two-pipe hydronic distribution system with DOAS units for ventilation air and fan-coil units for space conditioning.
 - 2. The project includes commissioning under the direction of a Commissioning Agent (CxA).
 - 3. The project will be LEED certified.
- F. See Division 01 for requirements related to LEED certification, commissioning, Owner's occupancy of the premises, limits on use of site, time restrictions on work, limits on utility outages or shutdowns, and phasing (sequencing) and scheduling.

1.26 PRODUCT OPTIONS

- A. Except as modified by provisions of Bidding and Contracting Requirements and Division 01, these options apply to Division 23 specifications.

- B. General: Where Contractor is permitted to use a product other than the specified item and model named as the basis of design, Contractor is responsible for all coordination and additional costs as specified in the article "Substitutions," below for substitutions.
- C. Products specified by reference standards or by description only: Any product meeting those standards or description.
- D. Products specified by naming one or more manufacturers, or model name or catalog reference number: Products specified establish a standard of quality, options to be included, and performance.
 - 1. Where other acceptable manufacturers are named, Contractor may provide products of those named manufacturers only, which meet the specifications.
 - 2. Where specification permits "equal" products, without naming other acceptable manufacturers, Contractor may use products of any manufacturer, which meet the specifications.
- E. Products specified by naming one manufacturer and particular product, with no provision for other options: No options or substitutions allowed.

1.27 SUBSTITUTIONS

- A. Substitutions will be considered only as permitted or required by the Bidding and Contracting Requirements and Division 01. Except as modified by those requirements, the requirements below apply to Division 23 specifications.
- B. Substitutions may be considered when a product becomes unavailable through no fault of the Contractor.
- C. Document each request with complete data substantiating compliance of proposed substitution with contract documents.
- D. A request constitutes a representation that the Bidder or Contractor:
 - 1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product.
 - 2. Will provide the same warranty for the substitution as for the specified product.
 - 3. Will coordinate installation and make changes to other work which may be required for the work to be complete with no additional cost to Owner.
 - 4. Waives claims for additional costs or time extension which may subsequently become apparent.
 - 5. Will reimburse Owner for review or redesign services associated with re-approval by authorities.
- E. Substitutions will not be considered when they are indicated or implied on shop drawing or product data submittals, without separate written request, or when acceptance will require revision to the Contract Documents.
- F. Substitution submittal procedure is specified in Bidding and Contracting Requirements and Division 01.

1.28 MATERIALS AND EQUIPMENT

- A. All materials and equipment shall be new and the best of their respective kinds, suitable for the conditions and duties imposed on them by the project and of representative manufacture. The description, characteristics and requirements of the materials to be used shall be in accordance with the specifications.
- B. All equipment, construction and installation must meet requirements of local, state and federal governing codes.
- C. Singular number: In cases where material, a device, or part of the equipment is referred to in the singular number in the specifications, it is intended that such reference shall apply to as many items of material, devices, or parts of the equipment as are required to complete the installation as shown on the drawings or required for proper operation of the system.
- D. Terms have the following meanings:
 - 1. Furnish: Supply item
 - 2. Install: Mount and connect item
 - 3. Provide: Furnish and install.
- E. All materials and equipment shall be installed and completed in a first class and workmanlike manner and in accordance with the best modern methods, practice and manufacturers' instructions. Any work which shall not present an orderly and neat or workmanlike appearance shall be removed and replaced with satisfactory work when so directed in writing by the Architect.
- F. The specifications and drawings are intended to define the minimum requirements, as to quality of materials, construction, finish and overall workmanship.
- G. General Conditions describe the correlation and intent of the Contract Documents. In case of discrepancies between the specifications and drawings, the specifications should be followed as to the general methods and principles and the drawings followed as to sizes, capacities and specifics for corresponding parts. If sizes are omitted, the Architect will determine sizes to be utilized.
- H. In all cases of doubt, uncertainty, or conflict as to the true meaning of the specifications or drawings, it is the responsibility of the Contractor to notify the Architect of said uncertainty, doubt, or conflict and obtain a decision as to the intent before starting any work which may be affected by this decision.

1.29 COORDINATION

- A. Should a situation develop during construction to prevent the proper installation of any equipment or item where shown on the drawings, call the situation to the attention of the Architect and await a written decision.
- B. Plan and coordinate all work to proceed in an orderly and continuous manner without undue delay, and in conformance with project schedule. Submit samples, shop drawings, schedules, insurance policies and certificates, and the like in time to avoid delays in actual construction. Coordinate HVAC work so that work of each trade is completed before other construction begins which would obstruct it.
- C. Coordinate trades to ensure that proper clearances between work of the various trades allow access to items which require operation and maintenance.

- D. Coordinate location and elevation of all piping, ductwork, light fixtures, equipment, and appurtenances in such a manner that the finished installation is as indicated on drawings. In the event difficulties are encountered which prevent this, it is the Contractor's responsibility to bring this to the attention of the Architect prior to initiation of work. Correct improperly coordinated installation at no additional cost.
- E. The Contractors' assistants shall include a competent foreman, who shall be on the premises at all times to check, lay out, coordinate and superintend the installation of work. The foreman shall establish all grades and lines relative to the work before starting, and be responsible for the accuracy thereof.

1.30 SUBMITTALS

A. Manufacturers' and subcontractors' lists:

- 1. As specified in Division 01, submit a complete list of proposed manufacturers for all equipment, materials and subcontractors used for the work of this division. Lists shall follow the sequence of the specifications. No considerations will be given for partial or incomplete lists. After review of lists, submit shop drawings and product data.

B. Shop drawings and product data:

- 1. Submit in accordance with the requirements of Division 01 or as established at the preconstruction conference, the required number of copies of shop drawings and product data for every item of equipment. Shop drawings or product data will not be considered until manufacturers' lists have been approved. Shop drawings and product data shall be submitted, as required by the General Conditions, with sufficient time for checking, return to Contractor, and resubmission as required before Contractor shall install any item.
- 2. Each item submitted shall be properly labeled, indicating the specific service for which the equipment or material is to be used, section and paragraph number of specification or drawing number to which it applies, Contractor's name and project name and number. Data submitted shall be specific and shall include product data and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents. Clearly identify each item within the data. Data of a general nature will not be accepted. Each sheet must clearly show the project name and number.
 - a. For roof-mounted equipment, submit manufacturer's certified drawings and other coordination drawings as required so that openings can be framed through the roof in accordance with structural requirements.
- 3. The review of a shop drawing or product data shall not be considered as a guarantee of the measurements or building conditions or that the shop drawings or product data have been checked to see that item submitted properly fits the building conditions. This review shall not relieve the Contractor of the responsibility for furnishing material or performing work as required by the contract documents, for correctness of dimensions and quantities, or for proper coordination of details and interfaces among trades.
- 4. All exclusively electrical items furnished as items associated with mechanical items but not specifically described in the mechanical item submission, shall be submitted as a separate submittal but shall be clearly marked as associated with the mechanical item by identification specification paragraph.
- 5. Product data sheets shall be 8.5-inches by 11-inches cut sheets for operating and maintenance manual.

- C. Submit at least three copies of the results of every test required under any section in this division.
- D. Specialist shall submit a list of at least three projects similar to this project in type, size, and quality, which have been in place and operating satisfactorily for at least five years.
 - 1. Include project name, address, name and phone number of owner's representative, and project type and size.
- E. After the work is completed, submit all required certificates of approval from approved inspection agencies and authorities having jurisdiction over work of this division. Certificates of approval must be received by the Architect prior to final acceptance of the work.

1.34 SPECIALIST

- A. The term "Specialist" as used in the specification shall mean an individual or firm of established reputation (or, if newly organized, whose personnel have previously established a reputation in the same field,) which is regularly engaged in, and which maintains a regular force of workers skilled in either (as applicable) manufacturing or fabricating items required by the contract, installing items required by the contract, or otherwise performing work required by the contract. Where the specification requires installation by a specialist, the term shall also be deemed to mean the manufacturer of the item, an individual or firm licensed by the manufacturer, or an individual or firm who will perform the work under the manufacturer's direct supervision.

1.35 CONTRACT CLOSEOUT SUBMITTALS

- A. Project record documents:
 - 1. Maintain on site one set of the following record documents; record actual revisions to the work of this division:
 - a. Contract drawings.
 - b. Specifications.
 - c. Addenda.
 - d. Change orders and other modifications to the Contract.
 - e. Reviewed shop drawings, product data, and samples.
 - 2. Maintain record documents separate from documents used for construction.
 - 3. Record information concurrent with construction progress.
 - 4. Specifications: Legibly mark and record in each section a description of actual products installed, including the following:
 - a. Manufacturer's name and product model and number.
 - b. Product options, substitutions, or alternates utilized.
 - c. Changes made by addenda and modifications.
 - 5. Record documents and shop drawings: Legibly mark each item to record actual construction, including:
 - a. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
 - b. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the work.
 - c. Field changes of dimension and detail.
 - d. Details not on original Contract Drawings.

6. Submit documents as specified in Division 01.

B. Operation and maintenance data:

1. Submit sets prior to final inspection as specified in Division 01. Unless otherwise specified in Division 01, submit no fewer than three sets. In addition to requirements specified in Division 01, submit operating and maintenance manuals for the work of this division as specified below.
2. Lubrication charts: Prepare lubrication charts for each piece of mechanical equipment that requires grease or oil.
 - a. Include the following:
 - 1) Types of lubricants required.
 - 2) Locations of lubrication points.
 - 3) Frequency of lubrication.
 - b. Provide one extra set of lubrication charts mounted in plastic covers, besides those required in Operating and Maintenance Manuals.
3. Binders: Provide large enough binders, and sufficient quantity, that the required contents can be easily turned, removed, and reinserted.
 - a. Self-expanding fast lock type.
 - b. Three telescoping metal posts.
 - c. Durable plastic covers.
 - d. Angle spline with guide flanges.
 - e. Text page size - 8.5 by 11 inches.
 - f. Boorum and Pease, Stock No. C-619-3 expansion 3 inch to 5 inch, or Stock No. C-1219 expansion 1-1/2 inch to 2-1/2 inch, or equal by National or Wilson Jones.
4. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS," and title of project. Print on spine of binder "O & M INSTRUCTIONS." If more than one binder is required, print covers and spines with volume numbers. Include in the front of every binder an index to all binders.
5. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.
6. Contents: Prepare a Table of Contents for each volume, with each product or system description identified, typed on white paper.
7. Part 1: Directory, listing names, addresses, and telephone numbers of mechanical engineers; Contractor; mechanical subcontractors; and major mechanical equipment suppliers.
8. Part 2: Operation and maintenance instructions, arranged by specification section. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers. Identify the following:
 - a. Significant design criteria, including pump and fan curves and similar performance charts.
 - b. List of equipment, including operating weight of each piece.
 - c. Parts list for each component, including recommended spare parts list.
 - d. Operating instructions.
 - e. Maintenance instructions for equipment and systems.
 - f. Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.
 - g. Valve charts, including locations of flow fittings.

- h. New burner installations: Include firing rate, nozzle size, and fuel pressure.
- 9. Part 3: Project documents and certificates, including the following:
 - a. Shop drawings and product data.
 - b. Air and water balance reports.
 - c. Photocopies of certificates.
 - d. Photocopies of warranties and guarantees.
 - e. Test reports: Copies of the results of all tests required under all sections of specifications.
- 10. Submit one copy of completed volumes in final form 15 days prior to final inspection. This copy will be returned after final inspection, with Engineer comments. Revise content of documents as required prior to final submittal.
- 11. Submit final volumes revised, within ten days after final inspection.
- 12. Submit DVD optical disc storage media specified in Section 230500.

1.42 REGULATORY REQUIREMENTS

- A. When these specifications call for materials or construction of a better quality or larger sizes than required by the following codes and standards, the provisions of the specifications shall take precedence.
- B. Provide, without extra charge, any additional materials and labor which may be required for compliance with these codes and standards even though the work is not mentioned in these specifications or shown on the contract drawings.
- C. Perform the work of this division in strict accordance with the following authorities. The latest revision of these codes accepted by the authority having jurisdiction as of the date of the contract documents shall apply.
 - 1. The plumbing, mechanical, electrical, building, fire, and safety codes of the state and county or city in which the work is being performed.
 - 2. The National Electric Code, NFPA 70 (NEC).
 - 3. The National Fire Protection Association Code. (NFPA).
 - 4. International Energy Conservation, Fire, Fuel Gas, Mechanical, and Plumbing Codes (ICC).

1.43 REFERENCE STANDARDS

- A. Perform the work of this division using the standards of the following organizations, as referred to in technical sections, as a minimum requirement for construction and testing. Unless specified otherwise in Bidding and Contract Documents or Division 01, the latest revision current as of the date of the contract documents shall apply. Products shall be certified by manufacturers to meet the requirements of referenced standards.
 - 1. Air Conditioning and Refrigeration Institute (ARI)
 - 2. Air Movement and Control Association (AMCA)
 - 3. Associated Air Balance Council (AABC)
 - 4. American Association State Highway and Transportation Officials (AASHTO)
 - 5. American National Standards Institute (ANSI)
 - 6. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - 7. ASME International (ASME)
 - 8. American Society for Testing and Materials (ASTM)
 - 9. American Society of Sanitary Engineering (ASSE)
 - 10. American Water Works Association (AWWA)

11. International Code Council (ICC)
12. Manufacturer's Standardization Society of the Valve and Fittings Industry Inc. (MSS)
13. National Electrical Code, NFPA 70 (NEC)
14. National Electrical Manufacturer's Association (NEMA)
15. National Fire Protection Association (NFPA)
16. National Fuel Gas Code, NFPA 54
17. National Sanitary Foundation (NSF)
18. National Standard Plumbing Code (NSPC)
19. The Occupational Safety and Health Act (OSHA)
20. Piping and Drainage Institute (PDI)
21. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA)
22. Underwriters Laboratory Inc. (UL)
23. Maryland Occupational Safety and Health Act (MOSHA)

1.53 TEMPORARY STORAGE

- A. Maintain upon premises, where directed, a storage area, and be responsible for all contents within these areas. Provide all security measures necessary for this area.
- B. Area shall be maintained and shall be returned to original condition at the completion of the project.

1.54 PROTECTION

- A. Each trade and subcontractor is responsible for preventing damage and soiling of work performed by other trades or subcontractors. Each trade and subcontractor is responsible for providing temporary protection of its own work.
 1. Protect work from spills, splatters, drippings, adhesives, bitumens, mortars, paints, plasters, and damage from welding or burning.
 2. Protect finished work from damage, defacement, staining, or scratching.
 3. Protect finishes from cleaning agents, or grinding and finishing equipment.
 4. Protect adjacent and finished work from damage, using tape, masking, covers or coatings and protective enclosures.
 5. Coordinate installations and temporarily remove items to avoid damage from finishing work.
- B. Repair all damage or soiling to the complete satisfaction of the Architect; replace any materials or work damaged to such an extent that they cannot be restored to their original condition, all at no addition to the Contract Sum.
- C. Protect work stored in place and supplies stored in the building.
 1. Store materials and products, subject to damage from moisture, in dry locations. If necessary, protect in wraps or covers.
 2. Store plastics, other materials, and products subject to damage from heat or cold at manufacturer's recommended temperatures.
- D. Use of sidewalk or roadway areas outside of the property lines shall be with permission and approval of the local authorities having jurisdiction.

1.55 FIRE PROTECTION

- A. As a minimum, provide hand-carried, portable, UL-rated extinguishers with each work crew working inside the building.
- B. Select extinguishers in accordance with NFPA 10 and NFPA 241 for classification, extinguishing agent, and size required by location and class of fire exposure.

1.60 PROJECT CONDITIONS

- A. Drawings showing utilities in concealed locations are based on the best information available but are not represented as being precisely correct. Work of the contract includes digging, cutting, drilling, using nondestructive methods, and other methods of locating concealed utilities in the field, as well as patching and repairing as specified in "Cutting and Patching" below.
- B. If, in the course of the work, workers encounter a material they suspect to present some hazard:
 - 1. Promptly notify the Architect in writing.
 - 2. Do not perform any work which would disturb the suspected material until written instructions have been received.

1.80 WARRANTY

- A. All work and equipment provided as work of this division shall be fully warranted under the general project warranty. In addition, provide added special warranties specified in individual sections.
- B. During the correction period, the Contractor shall promptly correct any work found to be not in accordance with the requirements of the Contract Documents, on receipt of written notice from the Owner. Except as otherwise required in General Conditions and Division 01, the correction period is two years after the date of substantial completion of the work. Work requiring correction shall promptly be repaired or completely replaced at no addition to the Contract Sum.
- C. When use of the permanent equipment has been permitted for temporary heating or ventilation of the building, the warranty and correction periods shall nevertheless begin at the time of substantial completion, unless another date of acceptance has been agreed to by the Owner.
- D. Special warranties are warranties required by individual specification sections, incidental product warranties, manufacturers' standard warranties, installer or subcontractor service agreements, and other individual warranties in addition to the general project warranty.
- E. Provide copies of warranties as required for Operation and Maintenance Manual specified above, and by Division 01.
- F. For items of work delayed beyond date of substantial completion, provide updated submittal within ten days after acceptance, listing date of acceptance as start of warranty period.

1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractors' and subcontractors' responsibilities are described in Division 01.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.11 CUTTING AND PATCHING

- A. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
- B. Cut walls, floors, partitions, roofs, and other appurtenances for the passage or accommodation of pipes, ducts and appurtenances. Close superfluous openings and remove all debris caused by work of this division.
- C. No cutting of any structure or finish shall be done until the condition requiring such cutting has been examined and approved by the Architect.
- D. New or existing surfaces disturbed as a result of such cutting or otherwise damaged shall be restored to match original work and all materials used for any patching or mending shall conform to the class of materials originally installed.
- E. Refinish surfaces to match adjacent finish. For continuous surfaces, refinish to nearest intersection or natural break. For an assembly, refinish entire unit.

3.14 TEMPORARY FACILITIES

- A. Temporary water facilities, electricity, telephone, toilet facilities, and temporary heat, shall be provided as specified in Division 01.

3.40 PROGRESS MEETINGS

- A. Progress meetings shall be held as specified in Division 01, and also when and if the Contractor or Architect finds them necessary or advantageous to progress of work.
- B. Contractor, those subcontractors and those material suppliers concerned with current progress or with the scheduling of future progress, Architect and Owner shall each be represented at these meetings by persons familiar with the details of work and authorized to conclude matters relating to work progress.

3.82 COMMISSIONING

- A. Comply with requirements of "Commissioning" in Part 1 above.

END OF SECTION 230101

SECTION 230500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Basic material and equipment required for the piping work as indicated on the drawings and specified in Division 23.
- B. Other requirements applicable to more than one section of Division 23.
- C. Identification of HVAC systems and equipment.

1.14 RELATED SECTIONS

- A. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.
- B. Project and special warranties: Division 01 and Section 230101.
- C. Operation and Maintenance Manuals: Division 01 and Section 230101.
- D. Painting: Division 09.

1.21 DEFINITIONS

- A. Project correction period: A period after Substantial Completion of the work during which the Contractor shall correct every part of the work found to be not in accordance with the requirements of the contract documents, promptly after receipt of written notice.
- B. Qualified testing agency: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ASTM E 548; and with additional qualifications specified in individual sections; and where required by authorities having jurisdiction, that is acceptable to authorities.
 - 1. NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7.
 - 2. NVLAP: A testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program.
- C. DN: Dimension Nominale, nominal pipe size in millimeters, in accordance with the metric system for construction, Systeme Internationale (SI).
- D. NPS: Nominal pipe size in inches, in accordance with standard U.S. designations for manufactured pipe. Pipe sizes do not change when projects are designed and built in metric units; each size has a consistent name (nominal dimension) in each system.

1.26 DESIGN REQUIREMENTS

- A. The drawings and system performances have been designed based on using the particular manufacturer's products specified and scheduled on the drawings.
- B. Products of other manufacturers that are listed under the article "Acceptable Manufacturers," or permitted as "equal," are permitted provided:

1. Product shall meet the specifications.
 2. Contractor shall make, without addition to the contract sum, all adjustments for deviations so that the final installation is complete and functions as the design basis product is intended.
- C. Do not propose products with dimensions or other characteristics different from the design basis product that render their use impractical, or cause functional fit, access, or connection problems.
- D. The contract drawings are generally diagrammatic and do not indicate all fittings or offsets in pipe, all access panels, or other specialties required.
1. Install pipe exposed to view parallel with the lines of the building and as close to walls, columns, and ceilings as may be practical, maintaining proper clearances for access at all parts requiring servicing.
 2. Install pipe a sufficient distance from other work to permit a clearance of not less than 0.5 inch (15 mm) between its finished covering and adjacent work.
 3. No pipe shall be run below the head of a window or door.
 - a. Equipment, ducts, and pipes installed in areas without a suspended ceiling shall be as tight to structure as possible, but at least above a height of 6'-8", unless otherwise noted.
 4. Pull boxes and other appurtenances which require operation or maintenance shall be easily accessible. Do not cut or form handholes for operation or maintenance of appliances through walls or ceilings.

1.30 SUBMITTALS

- A. Comply with Division 01 and Section 230101.
- B. Shop drawings:
1. Showing proposed expansion design.
 2. Schedule of welding and brazing procedures proposed for each piping system included in the project.
- C. LEED submittal:
1. Product data for Indoor Environmental Quality (IEQ) Credit 4.1: For adhesives and sealants, include printed statement of VOC content.
 2. Product data for Indoor Environmental Quality (IEQ) Credit 4.4: For wood products such as plywood equipment backboards, include printed statement of non-urea-formaldehyde component present in material.
- D. Certifications: Proof of operator and testing agency personnel qualifications as required for welding and brazing in the article "Quality Assurance" below.
- E. Test reports: Field test results for each piping system as specified in Part 3 below.

1.40 QUALITY ASSURANCE

- A. Provide materials and perform work in accordance with the plumbing, mechanical, electrical, building, fire, health and safety, and other applicable codes and regulations of the state, county or city in which the work is performed.

- B. Welding procedures and operator qualifications for structural welding: AWS D1.1, Structural Welding Code Steel, electric arc process.
- C. Welding, brazing, and soldering procedures and operator qualifications for building systems piping:
 - 1. AWS D10.9, Qualification of Welding Procedures and Welders for Piping and Tubing.
 - 2. ASME B31.9, Building Services Piping.
 - 3. Copper Development Association "Copper Tube Handbook."
 - 4. Safe Drinking Water Act.
- D. Electrical control panels, equipment, materials and devices provided or installed as work of Division 23 shall bear UL label or, if UL label is not available, the item shall be tested and labeled by a qualified testing agency, acceptable to authorities having jurisdiction, and in accordance with NFPA 70 (NEC). Provide testing, if required, without addition to the contract sum.
- E. Qualifications of DVD documentation technician: For video documentation specified in "Operating Instructions (Demonstration)," employ persons knowledgeable in DVD optical storage media format for video and audio production and editing.
- F. The project shall be LEED certified. See requirements specified in Division 01 and individual sections for LEED requirements, waste and air quality control.
- G. VOC content: Field-applied adhesives and sealants, limits per South Coast Air Quality Management District (SCAQMD), Rule No. 1168.
- H. Products shall contain no urea-formaldehyde content.

1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractors' and subcontractors' responsibilities are described in Division 01.

PART 2 - PRODUCTS

2.10 MATERIALS

- A. General piping techniques, testing, identification, painting, and operating instructions specified in this section apply to products specified in other sections of Division 23.
- B. Weldolets and thredolets: Fittings designed for installing branches on piping, with either welded or threaded connection to branch; conforming to ASTM A 234.
- C. Solder: Free of lead, antimony, and zinc and meeting the requirements of ASTM B 32. No solder containing lead is permitted.
 - 1. Tin 95.5 percent, copper 4 percent, and silver 0.5 percent; equal to "Silvabrite 100" manufactured by Engelhard Corporation.
 - 2. Tin, copper, bismuth, and silver; equal to "Oatey Silver" manufactured by Oatey.
- D. Flux: Meeting the requirements of ASTM B 813 and NSF 61 certified, equal to Oatey H-20⁹⁵.
- E. Pipe jointing compound:

1. Polytetrafluoroethylene (PTFE) pipe thread tape, "Teflon."
 2. Pipe cement and oil.
 3. For gas service: As specified in Section 23 1123, Natural-Gas Piping.
- F. Wood-preservative-treated lumber: Treated by pressure process, AWWA C2, with chemicals acceptable to authorities having jurisdiction, and marked with treatment quality mark of an inspection agency approved by ALSC Board of Review.
1. Application: Treat items indicated on the drawings, and the following:
 - a. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, or waterproofing.
 - b. Wood sills, sleepers, blocking, and similar concealed members in contact with masonry or concrete.
 - c. Wood framing and furring attached directly to the interior of below-grade exterior masonry or concrete walls.
 - d. Wood framing members that are less than 18 inches (460 mm) above the ground in crawlspaces or unexcavated areas.
 - e. Wood floor plates that are installed over concrete slabs-on-grade.

2.12 MATERIALS FOR BACKBOARDS FOR PIPING SPECIALTIES

- A. Provide wall-mounted backboards for mounting piping specialties consisting of plywood board, supports, and fasteners.
1. Backboard: Moisture-resistant marine plywood, locations and sizes as indicated on the drawings.
 2. Supports: Vertical backing rails, corrosion resistant, consisting of FRP composite structural shapes as indicated on the drawings.
 3. Fasteners: Corrosion-resistant fasteners suitable for secure anchorage into wall construction behind backboards.
- B. Marine plywood: BS-1080, Veneer Grade A/B, moisture-resistant marine plywood, spruce-pine-fir multiple ply, 5-ply minimum, pressure-treated construction, 0.563-inch (14-mm) thick minimum
- C. Fiber reinforced plastic (FRP) composite structural shapes: ASTM D 635 and E 84, Pultruded FRP structural shapes, non-corrosive, flame retardant, thermosetting polyester resin, composite factory-fabricated shapes for assorted assemblies and field erection.
1. Ultimate tensile strength: 30,000 psi (207 MPa).
 2. Modulus of elasticity: 2.8×10^6 psi (19,300 MPa).
 3. Specific gravity: 1.6 to 1.75.
 4. Density: 0.062 to 0.070 pounds/cubic inch (1.72 to 1.94 grams/cubic centimeter).
 5. Flame spread: ASTM E 84 Class A, 25 maximum.
 6. Color: Yellow.
 7. Shapes and sizes as indicated on the drawings
 8. Submit shop drawings of assemblies.
 9. Acceptable manufacturers:
 - a. Bedford Reinforce Plastics Company
 - b. Composites USA, Inc.
 - c. Liberty Pultrusions, Inc.
 - d. Strongwell Corporation
 - e. Structural Fiberglass, Inc.

- f. Or approved equal.

2.21 IDENTIFICATION DEVICES AND MATERIALS

A. Stenciling materials:

1. Stencils: Manufactured standard stencils prepared for required applications, conforming to ANSI A13.1 for color and size of legend letters, including arrows showing direction of flow.
2. Paint: Exterior type enamel, colors conforming to ANSI A13.1, or black.

B. Equipment identification tags:

1. Laminated plastic with adhesive back, white core and black outer layers, which, when engraved, will produce white letters and numerals on a black background.
2. Tags installed on curved surfaces shall be aluminum or brass.

C. Valve tags: Brass, 1.5 inch (40 mm) in diameter with black-filled numbers not less than 0.25 inch (6 mm) high, complete with brass attachment chains.

D. Ceiling identification tags: Laminated plastic with adhesive back, engraved black letters on white background, minimum 0.5 inch (15 mm) wide and length as required for 0.375 inch (10 mm) high letters for name of concealed device and number.

2.23 DATE-SENSITIVE EQUIPMENT

A. Date-sensitive equipment: Systems, equipment, or components which use or process date and time data in order to perform their functions.

B. Each item of date-sensitive equipment used in the project shall be warranted by the manufacturer to properly function and correctly use or process all time-related data for all dates and times which occur during a reasonable life expectancy of the equipment.

PART 3 - EXECUTION

3.03 INSTALLATION OF PRODUCTS AND EQUIPMENT

A. Manufacturers' instructions: Except as modified by drawings or specifications, install products and equipment in accordance with manufacturers' instructions and recommendations applicable to the project conditions.

1. Immediately notify Architect if a difference or discrepancy is found between manufacturers' instructions and the drawings or specifications.

3.22 PIPE INSTALLATION

A. Remove burrs resulting from cutting pipe or from any other operation.

B. Threaded connections:

1. Cut threads full and clean.
2. Apply specified pipe jointing compound or tape on male threads only.
3. Where piping is installed in crawl spaces and tunnels, cover exposed threads with either bituminous protective coating or rust-inhibitive paint. Apply after joints have been assembled and tested.

- C. Thoroughly clean pipe and fittings before they are installed, and keep them clean until the acceptance of the completed work. Cap or plug the ends of the lines so as to prevent earth and other debris from entering during construction.
- D. Provide for expansion and contraction of piping and connections so that no strain or breakage will occur. Provide anchors and guides of approved design where shown on drawings and where necessary to allow for proper expansion and contraction. At the time of installation, expansion loops shall be cold sprung to one-half of the calculated expansion.
- E. Provide for draining all parts of water piping systems and apparatus by installing a valved hose connection at every low point.
- F. Black steel piping NPS 2.5 (DN 65) and larger shall be welded; NPS 2 (DN 50) and smaller shall be threaded, except as required otherwise in a particular section.
- G. Do not weld galvanized piping.
- H. Use welding fittings, tees, wyes, reducers, eccentric reducers, and caps as required. Branches at least two nominal pipe sizes less than the main may be made with "Weldolets" or "Thredolets" installed with full size opening in larger pipe and in accordance with manufacturer's printed instructions. Flanges shall be welded neck or slip-on pattern of class to suit the valves or equipment connections. Flanges shall have machine bolts with hex nuts and washers.
- I. Each connection from risers to equipment shall contain at least three elbows or expansion joints. Connections shall be so arranged that movement in piping due to expansion and contraction will not be transmitted to the equipment.
- J. Install unions and flanges in the piping at each item of equipment, control valve, and appliance, so as to provide easy removal of the equipment, valve, or appliance, and to provide for easy removal of coils.
- K. Pitch water piping so that air in the system can be properly vented. Provide stop valves where necessary to isolate parts of system for repairs without draining the entire system.
- L. Special techniques: Follow the techniques for soldering and brazing pipe, fittings, and valves as recommended by the manufacturer.

3.23 COPPER TUBING FOR WATER INSTALLATION

- A. Solder joints for copper tubing: Clean ends of tubing and inside of fitting ends thoroughly with emery cloth before applying flux.
- B. Make flare joints in copper tubing with proper size flaring tool and in accordance with manufacturer's recommendations.
- C. Provide isolation fittings between copper and steel piping to prevent electrolysis.
- D. Cut pipe with a tubing cutter or fine-tooth saw. Cuts made with a saw shall be true and square, and the end shall be filed smooth with a fine-tooth file. Remove all marks and burrs with sandpaper.

3.24 PLASTIC PIPING INSTALLATIONS

- A. Cut pipe true and square with a fine-tooth saw and file the end smooth with a fine-tooth file. Remove all saw marks and burrs with sandpaper.
- B. Clean connecting surfaces of both pipe and fitting with methyl ethyl ketone or acetone.
- C. Apply solvent cement liberally with clean brush, first to fitting and then to pipe (outer surface and end). Lap cement a minimum of 0.25 inch (6 mm) over depth of fitting.
- D. Join pipe and fitting to full depth of fitting, giving fitting at least one-quarter turn on pipe to distribute cement.
- E. Pipe and fitting shall show a small fillet or bead completely around pipe without any voids, or fitting shall be cut out and new fitting made up and installed. Allow a minimum of 48 hours drying time for each joint.

3.25 INTERFACE WITH OTHER PRODUCTS

- A. Where it is necessary to run pipes through walls, provide finished, permanent, waterproof installation complete with inserts, sleeves, supports or hangers, seals, and other appurtenances as required. Do not pierce, cut, or notch any footing or other structural member.
- B. Waterproofing and dampproofing of the building shall be unharmed by the installation of the work. Where pipe has to pierce waterproofing or dampproofing, including outside walls, the penetration shall be made watertight. Waterproofing damaged or destroyed shall be repaired or replaced with new waterproofing.

3.59 IDENTIFICATION

- A. General: Do not apply identification until insulation and finish painting work is complete.
- B. Equipment:
 - 1. Stencil equipment with minimum two-inch (50-mm) -high letters or provide identification tags. Clearly indicate equipment designation and area served.
 - 2. Firmly fasten each identification tag to its appropriate piece of equipment with drive screws, sheet metal screws, or rivets. Do not interfere with operation of, or damage the item being marked.
- C. Piping:
 - 1. Mark by stenciling.
 - 2. Mark to identify service with arrows showing direction of flow. Apply markings near building walls where pipes enter or leave an accessible space and in intermediate locations so that markings are no more than 30 feet (9 m) apart. They shall be readily visible to a person standing on the floor.
 - 3. Fully identify all piping installed as work of the project.
 - 4. Mark pipe with letters of height and with colors as required by OSHA and conforming to ANSI A13.1.
 - 5. Identify every thermometer, gage, and control device.
 - 6. Provide valve tags for all valves except stop valves on individual fixtures or equipment where their function is obvious, or where the fixture or equipment is immediately adjacent. Numbers shall correspond to those shown on the Valve Chart. Attach tags to valve shaft.

- D. Stencil ductwork after insulation is applied, if required, with minimum two-inch (50-mm)-high letters, clearly identifying service (supply, return, exhaust) and showing direction of flow with arrows. Mark ducts near the building walls where they enter or leave a space, and at intervals of not more than 30 feet (9 m). Identification shall be visible to a person standing on the floor.
- E. Ceiling identification tags: Provide on the access door or, in suspended ceilings, on the ceiling support adjacent to the unit.
 - 1. Valves: Identify with the same number shown on the valve tag.
 - 2. Terminal units above ceilings: Identify with unit description and number.

3.61 PIPING TESTS

- A. Notify Owner at least one day prior to the actual test.
- B. Test before pipes are concealed or insulated. Test the piping in sections as the work progresses, so as not to delay progress of the building construction. Furnish pumps and gages required for testing.
- C. Conduct piping tests before connecting equipment that would be subject to damage from the test pressure. Replace piping or fittings found defective with new material.
- D. Bracing and supporting: Adequately brace and support piping during the test, so that no movement, displacement, or damage results from the application of the test pressure.
- E. Refrigerant piping: Test as specified in Section 232300.
- F. Test the piping systems for not less than four hours to fulfill the conditions in the Piping Systems Test Schedule at the end of this section.
- G. Documentation of tests: Prepare a test report for each portion of piping tested, identified by service, material, location, and pipe size. Include these items:
 - 1. Date of test.
 - 2. Starting and completion times.
 - 3. Initial test pressure.
 - 4. Final test pressure.
 - 5. Problems or leaks detected.
 - 6. Corrective actions taken.
 - 7. Record of successful completion of testing.
 - 8. Name, title, and signature of person conducting test.

3.75 CLEANING AND PAINTING

- A. Cleaning: Clean all piping and equipment. Where items are to be painted, clean ready for painting.
- B. Painting: Coordinate painting with requirements of Division 09. Paint the items identified below to be painted. Use paint materials and systems specified in Division 09.
- C. Items to be painted:
 - 1. Items identified below to have protective coating.

2. Items furnished with manufacturer's prime coat.
 3. Mechanical rooms (including boiler, chiller, and air-handling unit rooms):
 - a. Insulation and uninsulated steel: Piping, pumps, tanks, and vessels.
 - b. Hangers and supports.
 4. Piping and ductwork exposed in finished spaces, insulated and uninsulated.
 5. Inside ducts behind registers, grilles, and diffusers.
- D. Items not to be painted: Copper, stainless steel, and equipment furnished with manufacturer's finish.
- E. Paint systems in mechanical rooms: Paint piping using colors in accordance with ANSI A13.1.
1. Galvanized steel: One coat of primer recommended for galvanized surfaces and one coat of glossy alkyd enamel.
 2. Ferrous metal: One coat of primer recommended for ferrous metal and one coat of glossy alkyd enamel.
 3. Items protected with bituminous coating or rust-inhibitive primer: Finish coat of compatible glossy enamel.
- F. Paint systems for exposed piping and ductwork: Primer compatible with the substrate, whether steel, galvanized steel, insulation jacket, or other material; one coat or two, if required to cover, to match adjacent surfaces in color and texture.
- G. Painting inside ducts behind registers, grilles, and diffusers: Matte black, compatible with substrate and suitable for the temperatures at which the duct will operate, extending from the duct opening to a depth such that no unpainted surface will be visible to a person standing on the floor or adjacent balconies.
- 3.81 OPERATING INSTRUCTIONS (DEMONSTRATION)
- A. Furnish the necessary technicians, skilled workers, and helpers to operate all the HVAC systems and equipment of the entire project for one 8-hour day.
 - B. Where specified in technical sections, provide longer periods required for specialized equipment.
 - C. Instruct the Owner or designated personnel in operation, maintenance, lubrication, and adjustment of all systems and equipment.
 1. Instructions by manufacturer's technical representative for each type of equipment shall include the performance of the recommended preventive maintenance procedures for that equipment.
 - D. The Operating and Maintenance Manual shall be available at the time of the instructions, for use by instructors and Owner personnel.
 - E. Record each instruction session only in DVD media format (video and audio format), including both the sessions specified above and added sessions required in technical sections for specialized equipment. Provide one complete set of DVDs with each Operating and Maintenance Manual.
 - F. Schedule the general and specialized instruction periods for a time agreed upon by the Owner and Architect.

3.90 SCHEDULES

A. Piping Systems Test Schedule:

SYSTEM	TEST PRESSURE PSIG (kPa)	ALLOWABLE DROP	MEDIUM
Heating water	125 (860)	None	Water
Chilled and chilled/heating water	125 (860)	None	Water
Fuel gas	100 (690)	None	*Air

* If pressure drops, locate leaks with soap and water solution

END OF SECTION 230500

SECTION 230501 - EXCAVATION AND FILL FOR HVAC WORK

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Trenching, backfilling, and compacting for HVAC work underground inside the building and extending five feet beyond exterior building walls.
- B. Restoring and reseeding grassed areas.

1.14 RELATED SECTIONS

- A. Cutting and patching: Division 01 and Section 230101.
- B. Repairing pavements: Division 32.
- C. Piping: Sections 231123, 232113, and 232115.

1.20 REFERENCES

- A. ASTM D 1557: Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbs/cu ft (2700 kN-m/cu m).

1.30 SUBMITTALS

- A. General: Submit in accordance with Division 01 and Section 230101.
- B. Shop drawings: At the same scale as the contract drawings, showing field verified locations of utilities, and proposed detailed trenching plan.
- C. Product data:
 - 1. Warning tape
 - 2. Seed and mulch
- D. Certifications: Test reports showing that compaction meets specified requirements.

PART 2 - PRODUCTS

2.10 MATERIALS

- A. Backfill: Earth materials, free from perceptible amounts of wood, debris, or topsoil, free of frost at the time of placement, and not containing marl or other elements which tend to stay in a plastic state.
- B. Underground warning tape: Polyethylene 0.004 inch (0.102 mm) thick for metallic lines, and for non-metallic lines polyethylene both sides with metallic lining, six inches (152 mm) wide.
 - 1. Colors: In accordance with APWA and AASHTO standards.
 - 2. Markings: Repeated continuously along the entire length, legend appropriate for line being identified.

- C. Grass seed: Fresh new-crop seed, 90 percent pure and 85 percent germination. Mix: 70 percent Kentucky Bluegrass, 25 percent Red Fescue and 5 percent Red Top. Only strains of Kentucky Bluegrass found adaptable to Maryland shall be acceptable.
- D. Mulch: Free of sticks, weeds, or other foreign matter; either licorice root, tan root, or tan bark; fibrous by-product of extraction. Use only one type throughout the project.

2.12 EQUIPMENT

- A. Mechanical tampers for compacting backfill: Capable of exerting a blow equal to 250 pounds per square foot (12 kPa) of area of the tamping face.

PART 3 - EXECUTION

3.05 PREPARATION

- A. Contact local utility company underground information service (BGE Miss Utility) before beginning excavation outside buildings.
- B. The general locations of underground utilities are indicated on the drawings and are not to be assumed to be accurate or complete. Before beginning work, field check the area with the most accurate instruments available, such as Fisher Labs' Pipe and Cable Locators.

3.20 INSTALLATION

- A. Perform all excavating, cutting of paved areas, trenching, sheeting, shoring, backfilling, and compacting required for the proper installation of the work. Repair of pavement is specified in Division 32.
- B. Where obstructions are encountered, obtain written approval and make necessary changes in line, grade or location.
- C. Protect existing utilities from damage during excavation and backfilling. Repair damaged new or existing work at no addition to the contract sum. Bracing, shoring and other protection of existing utilities is part of this work.
- D. Do not damage or remove existing shrubs or trees including their root systems, without prior notification to the Architect.
- E. Provide temporary roadways over trenches with railings and other safeguards, including amber blinker lamps or other warnings for night use.
- F. Note the depths of footings. In cases where piping is in close proximity to or below footings and where the natural earth under footings is disturbed, after the line is installed the voids shall be filled up to bottoms of such footings with solid concrete.

3.24 CUTTING

- A. Cut concrete and asphalt concrete with masonry saw prior to breaking it into smaller pieces for removal.
- B. Cut sidewalks perpendicular to the length at the closest existing joint that is a minimum of 24 inches back from either side of the top of the new trench.

3.25 TRENCHING

- A. Excavations inside the building shall be carefully planned. Stockpile excavated earth so as not to interfere with other construction. Dig trenches to the proper depths, providing extra depressions where required for hubs of pipes.
- B. Excavations outside the building shall generally follow the routes indicated on the drawings. Stockpile topsoil separately for later replacement. Excavations shall be of sufficient depths to provide, unless indicated otherwise on the drawings, a minimum cover as follows:
 - 1. Water piping: 42 inches (1067 mm).
 - 2. Fuel piping: 30 inches (762 mm).
- C. Trenches shall be of necessary depth and width for the proper laying of pipe with a minimum of 8 inches (205 mm) on each side of the joint.
 - 1. The sides shall be as nearly vertical as practicable. Unless local regulations are more strict, trenches 4 ft. (1220 mm) and deeper shall have shored sides as required by OSHA trenching regulations.
 - 2. The bottoms of trenches shall be accurately graded to provide uniform bearing and support for each section of pipe on undisturbed soil at every point along its entire length, except for bell holes and for the proper sealing of the pipe joints.
 - 3. No greater length of trench shall be left open, in advance of the completed structure placed in it, than can be completed in that day's operation.
 - 4. Except where rock is encountered, do not excavate below the depths required. Where rock excavation is required, excavate to a depth of at least 6 inches (150 mm) below the trench depth and fill the overdepth with compacted crusher run or bank run stone or sand. Unauthorized overdepths in excavation shall be backfilled with crushed stone, slag or gravel, thoroughly compacted.
 - 5. Whenever wet or otherwise unstable soil is encountered, it shall be removed to the depth and extent directed, and the trench backfilled to the proper grade with crushed stone, slag or gravel.
- D. Should springs be encountered within the work area, or soft soil conditions at the elevations required for load bearing, immediately notify the Architect and do not place any portion of the work on such surfaces until instructions are received.
- E. Furnish and maintain pumps, flumes, gutters, and appurtenances if required to keep the excavations free from water. Water shall be directed to a point remote from building operations, shown on the approved shop drawing.

3.26 BACKFILL

- A. Place no backfill until the adjacent construction or the utility to be covered has been inspected, tested, and approved.
- B. Installing underground warning tape: Install in backfill above exterior buried lines not encased in concrete. Select legend and color appropriate for type of line. Install metallic lined tape for non-metallic lines. Install approximately 12 inches (305 mm) below grade.
- C. HVAC systems backfill:
 - 1. Backfill and compact in six-inch (150-mm) layers up to spring line of the pipe. The installations shall then be inspected and tested.

2. Following inspection, backfill in six-inch (150-mm) layers, each compacted, until the pipe has a cover of not less than one foot (305 mm). Place the remainder of the backfill material in the trench in eight-inch (200-mm) compacted layers.
3. Excavations improperly backfilled shall be reopened, then refilled and compacted to the required grade and compaction, and smoothed off.
4. Open trenches across roadways or other areas to be paved shall be backfilled as specified above, except that the entire depth of trench shall be backfilled in six-inch (150-mm) layers, and each layer shall be mechanically compacted.
5. Completed work shall have uniform graded surface, in accordance with the surface and grade indicated on the drawings.

D. Structure backfill:

1. Do not backfill against structures with cement mortar joints until the mortar is at least twelve hours old.

3.27 COMPACTION

- A. Test in accordance with the requirements of ASTM D 1557.
- B. Compact under slabs, roads, and sidewalks to a 95 percent density.
- C. Compact unpaved areas to a 90 percent density.
- D. Backfill and compact trench in unpaved areas to within 4 inches (102 mm) of existing grade. Furnish and install compacted select topsoil for the final layer to finish even with existing grade. Remove surplus earth and rake unpaved areas for final planting.
- E. Take particular care in compaction of earth under joints of HVAC piping.

3.28 SEEDING

- A. Seed disturbed grass areas at the rate of 5 pounds (2.27 kg) per 1000 sq. ft. (92.9 sq. m), with the seed mix specified.
- B. Uniformly distribute seed with an approved machine to ensure a covering of plus or minus 1/4 inch (6 mm). Sow half of the seed in one direction and the rest at right angles.
- C. Do not seed during windy weather or when ground is wet or otherwise untillable. Seed between the dates of March 1st to May 1st or August 15 to October 15 unless otherwise approved in writing.

3.29 MULCHING

- A. Mulch seeded areas immediately following seeding with fibrous mulch evenly applied at an average rate of 2 tons per acre (4483 kg per hectare) so as to provide a loose depth of not less than 2 inches (50 mm).
- B. Wet down mulch, unless a heavy rain wets it, to the Architect's satisfaction, immediately after application.

3.41 RESURFACING

- A. Resurface sidewalks, roads, streets, and other paved areas as work of this section, matching the construction and finish of adjacent paving. Paving shall meet the requirements of Division 32.

END OF SECTION 230501

SECTION 230502 - SLEEVES AND PLATES FOR HVAC PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Sleeves and escutcheon plates for piping systems.
- B. Mechanical seals for piping penetrations.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: Sleeves, plates, sealants, and mechanical penetration seals.

PART 2 - PRODUCTS

2.10 SLEEVES, PLATES, AND ACCESSORIES

- A. Steel sleeves: Schedule 40 black steel pipe, ASTM A 53.
- B. Copper sleeves: Type L, ASTM B 88 hard drawn.
- C. Cast-iron sleeves: Extra heavy, equal to product of U.S. Pipe Co. with waterstop and ends as shown on the drawings.
- D. Plastic sleeves: Schedule 40 PVC, ASTM D 1785.
- E. Sealing compound in walls and floors: Equal to the following:
 - 1. Bare and insulated pipes carrying fluids 150 degrees F (65 degrees C) and below: Sika Corporation "Sikaflex - la."
 - 2. Bare and insulated piping carrying fluids 151 degrees F (66 degrees C) and above: Dow Corning Corporation "790 Silicone."
- F. Floor, wall and ceiling plates: Stamped or cast brass, hinged type as pipe size requires. Plates shall have chrome finish.
- G. Mechanical penetration seals: Equal to PSI "Link-Seal Modular Seals" or Calpico Sealing Link "LINX". Seals shall be modular mechanical type, consisting of interlocking synthetic links shaped to continuously fill the annular space between the pipe and wall opening. Bolt and nut fasteners for the seals shall be stainless steel for units used in penetrations below grade.

PART 3 - EXECUTION

3.20 INSTALLING SLEEVES

- A. Install sleeves for piping, or piping with insulation continuous through sleeve, passing through walls, partitions, beams, or slabs.
 - 1. Exception: Where steel pipe penetrates a steel beam that is not part of a fire- or smoke-rated assembly, no sleeve is required.

- B. Do not cut, drill, or burn structural steel for installation of piping without specific instructions from the Architect.
- C. Locations in nonfire-rated construction:
 - 1. Install steel sleeves for penetrations of steel, iron, and insulated piping.
 - 2. Install copper sleeves for penetrations of uninsulated copper tubing and piping.
 - 3. Install plastic sleeves for penetrations of plastic piping. Plastic piping and sleeves are not permitted in ceiling spaces used as HVAC system plenums, or in shafts used for building HVAC air distribution.
- D. Locations in floors and fire-rated construction: Sleeves used in piping penetrations through fire-rated construction shall be an acceptable component of the through-penetration firestop assembly as specified in Section 230507, Firestopping for HVAC Work.
 - 1. Where firestop assembly is UL listed, sleeve material shall be as directed in the listing.
 - 2. Where other specified approval and acceptance is required, sleeve shall be as described in the approved assembly.
- E. Install sleeves through walls and partitions flush with finished surfaces.
- F. Sleeves through floors shall extend 0.375 inch (10 mm) above top of finished floor and be finished neat and level. Sleeves through mechanical or equipment room floors shall extend one inch (25 mm) above finished floor. Provide projecting sleeves with anchor clips to prevent them from being loosened and knocked down in the floor construction.
- G. Sleeves for penetrations in kitchen and food service areas shall finish 0.375 inch (10 mm) above floor or flush with wall surfaces and be neatly pointed up to fit snugly against floor or wall materials. Seal space between pipe and sleeve with waterproof sealant or fire barrier as required, and finish even with wall or floor with a light pouring of molten lead.
- H. Sleeves for insulated piping with vapor barrier shall be large enough to pass piping and insulation.
- I. Seal spaces between sleeves and pipe, or pipe insulation, in nonrated walls, with mineral wool.
- J. Penetrations in exterior masonry or concrete walls and foundations:
 - 1. Sleeves: Cast iron, or in cast concrete may be core drilled.
 - 2. Above grade: Mechanical penetration seal at outside face of wall.
 - 3. Below grade: Mechanical penetration seals at outside and inside faces of wall.

3.25 INSTALLING PLATES

- A. Piping passing through interior walls, partitions, floors, and ceilings in exposed locations shall be fitted with wall, floor, and ceiling plates of size and depth to conceal sleeves. Secure plates firmly in place with set screws.
- B. Do not install floor or wall plates on pipes in the kitchen and food service areas.

END OF SECTION 230502

SECTION 230503 - ACCESS DOORS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Access doors for concealed HVAC specialties requiring maintenance or manual operation.

1.14 RELATED SECTIONS

- A. Valves: Section 230523.
- B. Specialties: Section 230508.
- C. Duct access doors: Section 233300.
- D. Controls: Sections 230901 through 230923.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: Each type of access door.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Wall and ceiling access doors:
 - 1. Acudor Products Inc.
 - 2. Cesco Products Company
 - 3. Karp Associates, Inc.
 - 4. Milcor, Inc.
 - 5. Zurn Industries

2.21 WALL AND CEILING ACCESS DOORS

- A. Doors: Provide Milcor model listed, or similar type and equal quality by another acceptable manufacturer.
- B. Types:
 - 1. Fire-rated where occurring in fire-rated walls.
 - 2. Style AP where occurring in acoustical plastered surfaces.
 - 3. Style K where occurring in hard plastered surfaces.
 - 4. Style M stainless steel where occurring in masonry or ceramic tile surfaces.
 - 5. Style DW where occurring in drywall construction.
- C. Sizes: As required for access to the particular device, but no less than 16 by 16 inches (405 by 405 mm).
- D. Finish: Brushed stainless steel.

2.70 LABELS

- A. For access doors to fire protection devices: OSHA and NFPA approved, describing the fire protection device within.
- B. Minimum lettering size: 0.5 inch (13 mm) high.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Provide access doors in walls and inaccessible ceilings for concealed damper operators, duct access doors, valves, and other concealed specialties and appliances that require manual operation or maintenance.
- B. Select appropriate size door for each particular application.

END OF SECTION 230503

SECTION 230505 - EQUIPMENT CONNECTIONS FOR HVAC

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Equipment connections for HVAC equipment.

1.14 RELATED SECTIONS

- A. Piping connections: Section 230500.
- B. Lists of accessories: Suppliers of equipment specified in other divisions.
- C. Wiring connections: Section 260521.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: Any product required for connection but not specified in other sections.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Connect to HVAC equipment. Install valves, balancing cocks, thermometer wells, gage tappings, control valves, air vents, strainers, and appurtenances as shown on diagrams on drawings and specified under other sections of the specifications.
- B. Connect to equipment requiring water, gas, or other piping connections, that is specified, furnished and set in place in other divisions or listed on the drawings.
- C. Provide water supply shutoff valves, gas shutoff valves, and unions at each item of equipment. Where exposed adjacent to chromium-finished piping, the water shutoff valves shall be chromium plated.

END OF SECTION 230505

SECTION 230506 - CURBS AND FLASHINGS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Curbs, rails, and flashing devices for HVAC items and equipment penetrating roof and mounted on roof.
- B. Sound deadening materials for curbs supporting rooftop equipment.

1.14 RELATED SECTIONS

- A. Rough carpentry: Division 06.
- B. Air-handling units: Section 237322.
- C. Rooftop packaged air-conditioning units: Section 237413.
- D. Energy recovery and dedicated outdoor air units: Section 237200.
- E. Ductwork: Section 233113.
- F. Fans: Section 233400.
- G. Ductless split-system units: Section 238127.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Shop drawings: Roof curbs and rails, showing compatibility with roof membrane, insulation, and slope, and configuration for the supported equipment.
 - 1. If curbs are provided by curb manufacturer, coordinate with approved shop drawings provided as specified in related equipment sections, to determine configuration of equipment requiring curb support.
- C. Product data: Each type of manufactured unit, accessory, and accessory material.
- D. Certifications: For sound deadening materials, statement signed by the Architect stating that he or she has inspected the installation of sound deadening materials in the roof curb(s) for rooftop unit(s) which include compressors and that the installation is in accordance with the specifications and drawings.

1.40 QUALITY ASSURANCE

- A. Curbs and rails may be the product of the manufacturer of the equipment they support, or of a roof curb and support manufacturer, provided they are equal to the products of the named manufacturers and meet this specification.

1.70 SEQUENCING

- A. Coordinate installation of rooftop equipment and supports with roof structure and membrane. Loads and penetrations shall not exceed or damage structural capacity or weathertightness.

PART 2 - PRODUCTS

2.10 MATERIALS

- A. Wood-preservative-treated lumber: As specified in Division 06 and in Section 230500.
 - 1. Application: Treat items indicated on the drawings, and the following:
 - a. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, or waterproofing.
- B. Sound control accessory materials:
 - 1. Sealant: One-part nonsag urethane sealant, equal to Sika Corp. "Sikaflex-1a," BASF "MasterSeal NP1," or Tremco "Dymonic."
 - a. Bond breaker: Polyethylene, or as recommended by sealant manufacturer.
 - 2. Exterior gypsum soffit board: 0.5-inch-thick.
 - 3. Embedding compound: As recommended by gypsum board manufacturer.
 - 4. Acoustical lining: ASTM C 1071, Type II, rigid, 2 inches thick, ASTM C 423 (Type A mounting) NRC at least 0.95.

2.20 PENETRATIONS OF SINGLE PIPE OR VENT

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified product, or comparable product by another manufacturer.
- B. Boot for water piping through flat roof: Equal to Elmdor/Stoneman Engineering and Manufacturing Co. 1100-4, 4-lb (1.8 kg per 0.09 sq. m) lead boot, 8-inch (205-mm) skirt; top counterflashing fitting and waterproofing compound.
- C. Vents through roof from steam or steam condensate return piping, and from steam condensate receivers: Stack flashing fitting designed for threaded connection to vent pipe and extension, with integral counterflashing, painted cast iron, equal to Josam 26440, or product of Zurn or Jay R. Smith.

2.21 PENETRATIONS OF GROUPS OF PIPES

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified product, or comparable product by another manufacturer.
- B. Where a group of pipes penetrates the roof, provide a curb assembly equal to RPS Corporation Style RC. Assembly shall include curb, cover, and boots and clamps for the number of lines shown on the drawing. Curb shall be a minimum of 18-gage galvanized steel, unitized construction with integral base plate insulated with 3-pound (48 kg/m³) density insulation, 2 by 2 inch (50 by 50 mm) nailer, acrylic-clad ABS plastic cover, and fastening screws. Boots shall be graduated step design EPDM rubber, with stainless-steel lock clamps.

2.22 CURBS AND RAILS

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified product, or comparable product by one of the following:
1. Curbs Plus, Inc.
 2. Pate Co.
 3. Roof Products & Systems (RPS) Corp.
 4. ThyCurb Division, ThyBar Corp.
- B. Fabricate each curb and rail in accordance with certified equipment drawings supplied by the equipment manufacturer, and with details on the drawings. Select style and configuration as required by roof membrane, insulation, and slope.
1. Height: At least 12 inches (305 mm) above top of insulation, except as otherwise shown on drawings.
 - a. Fans ventilating kitchen hoods: At least 24 inches (610 mm), or more if required to place discharge of fan 40 inches (1016 mm) above roof surface.
 2. Steel: 18 gage, galvanized.
 3. Construction: Monolithic, with all welded components, fully mitered corners, factory- attached wood nailer, and steel counterflashing.
 4. Insulation: Fiberglass board, 3 lbs (48 kg/m³) density, 1.5 inches (38 mm) thick.
- C. Curbs for condensing units 5 tons and smaller: Equal to Pate pedestal curb with solid top and “Dektite” flashing system, size to fit each unit.
1. Top: Plywood of adequate thickness and reinforcement to support unit, covered with no less than 18 gage galvanized steel counterflashing cap.
 2. Pipe and conduit flashings: EPDM with ribbed aluminum base with mounting holes for screws, designed for field mounting on curb.
 - a. Number: One for each pipe and conduit to the supported unit.
 - b. Size: To suit pipe and conduit required for the unit.

2.72 ROOFTOP PIPE SUPPORT SYSTEM

- A. Equal to Caddy “Pyramid ST” Series PSF UV-stabilized; polyethylene, polypropylene, and hot-dip galvanized strut-based support, 10 inches minimum strut length by 4 inches in height.
- B. Provide manufacturer’s standard pipe clamps and accessories designed for strut system, as required for size, material, and configuration of air-conditioning condensate lines across roof.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Flashing of roofing felts into clamping devices of sleeves through roof, and flashing and counterflashing of pipe curb assemblies and of roof rails and curbs shall be as specified under Division 07.

- B. Securely attach curb to roof construction with a 6-inch-(150-mm) wide wood frame the thickness of the roof insulation, with countersunk flat-head 0.375-inch (10-mm) diameter cadmium-plated through bolts with washer and double nuts on underside of structural framing around roof opening. Secure curb to wood frame with No. 10 cadmium-plated wood screws.
 - 1. Place bolts and screws on maximum 12-inch (305-mm) centers, with no fewer than two for each side of rail, curb, or frame.
- C. Where dissimilar metals would come in contact with each other, coat them with bituminous protective coating or other coating compatible with adjacent materials.

3.21 INSTALLING ACCESSORY SOUND-DEADENING MATERIALS

- A. Inside the perimeter of the curb, cover roof deck with gypsum board fit in tightly, joints and voids filled in with embedding compound, and edges sealed.
- B. Over gypsum board, install two layers of acoustical lining. Install one layer of gypsum board between the two layers of acoustical lining, and one over the top layer of acoustical lining. Fill joints and voids and seal edges of each layer of gypsum board.
- C. Applying sealant:
 - 1. Clean surfaces and install bond breaker.
 - 2. Install sealant to a maximum depth of 0.5 inch, minimum depth 0.25 inch. Sealant is moisture-cured; assure adequate exposure to air.
- D. Protect sound-deadening materials from weather until equipment has been installed and flashed weathertight.

3.22 INSTALLING ROOFTOP PIPE SUPPORT SYSTEM

- A. Where air-conditioning condensate lines cross roof from equipment to drain, support on rooftop support system.
- B. Use clamps and fasteners compatible with piping.
- C. Follow manufacturer's instructions.

3.60 FIELD QUALITY CONTROL

- A. Notify the Architect at least two days in advance of the time when the installation of sound-deadening materials will be complete. Do not cover the work until the Architect has inspected it and signed the certificate required in the article "Submittals" in Part 1 above, stating that the installation of sound deadening is in accordance with the specifications and drawings.

END OF SECTION 230506

SECTION 230507 - FIRESTOPPING FOR HVAC WORK

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Through-penetration firestopping in fire-rated construction.
- B. Through-penetration smoke-stopping in smoke partitions.

1.14 RELATED SECTIONS

- A. Sections specifying requirements for LEED rating are specified in Division 01.
- B. Sleeves and plates: Section 230502.
- C. Ductwork: Section 233113.

1.20 REFERENCES

- A. Underwriters Laboratories
 - 1. UL Fire Resistance Directory
 - 2. UL 1479: Through Penetration Firestops.
- B. American Society for Testing and Materials Standards:
 - 1. ASTM E 814: Standard Test Method for Fire Tests of Through-Penetration Firestops.

1.21 DEFINITIONS

- A. Assembly: Particular arrangement of materials specific to given type of construction described in referenced documents.
- B. Barriers: Time-rated fire walls, smoke barrier walls, time-rated ceiling/floor assemblies and structural floors.
- C. Firestopping: Methods and materials applied in penetrations and unprotected openings to limit spread of heat, fire, gasses and smoke.
- D. Penetration: Opening or foreign materials passing through or into barrier or structural floor such that full thickness of rated materials is not obtained.
- E. Sleeve: Metal fabrication or pipe section extending through thickness of barrier and used to permanently guard penetration. Sleeves are described as part of penetrating system in other sections and may or may not be required.
- F. System: Specific products and applications, classified and numbered by the rating agency to close specific barrier penetrations.

1.25 SYSTEM DESCRIPTION

- A. Design requirements:

1. Fire-rated construction: Maintain barrier and structural floor fire resistant ratings including resistance to cold smoke at all penetrations.
2. Smoke barrier construction: Maintain barrier and structural floor resistance to cold smoke at all penetrations.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. LEED submittal:
 1. Product data for Indoor Environmental Quality (IEQ) Credit 4.1: For penetration firestopping, including printed statement of VOC content and chemical components.
- C. Product data: Manufacturer's specifications and technical data including the following:
 1. Detailed specification of construction and fabrication.
 2. Manufacturer's installation instructions.
- D. Shop drawings: Submit firestop assemblies and devices for all openings and through penetrations in fire-rated construction. Indicate dimensions, description of materials and finishes, general construction, specific modifications, component connections, anchorage methods, hardware, and installation procedures, plus the following specific requirements.
 1. Details of each proposed assembly identifying intended products and applicable rating agency classification.
 2. Manufacturer or manufacturer's representative shall provide qualified engineering judgments and drawings relating to conditions where rated assemblies do not exist.
- E. Quality control submittals:
 1. Statement of qualifications.
- F. Applicators' qualifications statement:
 1. List past projects indicating required experience.
- G. Certifications: Letters or forms showing acceptance by local authorities for systems without acceptance by a rating agency.

1.40 QUALITY ASSURANCE

- A. Products and assemblies shall be tested and labeled by an independent, nationally recognized testing and labeling authority.
- B. Comply with requirements for LEED certification specified in Division 01.
- C. Installer's qualification: Firm experienced in installation or application of systems similar in complexity to those required for this project, plus the following:
 1. Acceptable to or licensed by manufacturer, state, or local authority where applicable.
 2. At least 2 years' experience with systems.
 3. Successfully completed at least 5 projects of comparable scale, using these systems.

- D. Local and state regulatory requirements: Obtain acceptance for proposed assemblies not conforming to specific rating agency classifications or rated assemblies.
- E. Materials shall have been tested to provide fire rating at least equal to that of the construction in which they are to be installed.
- F. VOC content: Field-applied adhesives and sealants, limits per South Coast Air Quality Management District (SCAQMD), Rule No. 1168.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Packing and shipping:
 - 1. Deliver products in original unopened packaging with legible manufacturer's identification.
 - 2. Coordinate delivery with scheduled installation date, allow minimum storage at site.
- B. Storage and protection: Store materials in a clean, dry, ventilated location. Protect from soiling, abuse, moisture and freezing when required. Follow manufacturer's instructions.

1.60 PROJECT CONDITIONS

- A. Environmental requirements:
 - 1. Furnish adequate ventilation if using solvent.
 - 2. Furnish forced-air ventilation during installation if required by manufacturer.
 - 3. Keep flammable materials away from sparks or flame.
 - 4. Provide masking and drop cloths to prevent contamination of adjacent surfaces by firestopping materials.
 - 5. Comply with manufacturing recommendations for temperature and humidity conditions before, during and after installation of firestopping.

1.80 WARRANTY

- A. General project warranty and correction period, as required in general conditions and Division 01, requires repair or replacement of materials or systems which fail in joint adhesion, co-adhesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, or general durability or appear to deteriorate in any other manner not clearly specified by submitted manufacturer's data as an inherent quality of the material for the exposure indicated.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers and products: Those listed in the UL Fire Resistance Directory for the UL System involved, or rated for the application by Warnock Hersey or by another acceptable rating agency.

2.20 THROUGH-PENETRATION FIRESTOPPING OF FIRE-RATED CONSTRUCTION

- A. Provide systems or devices listed and labeled by a rating agency, and conforming to the construction type, penetrant type, annular space requirements and fire rating involved in each separate instance. The system shall be symmetrical for wall applications. Systems or devices shall be asbestos-free.
 - 1. Additional requirements: Withstand the passage of cold smoke either as an inherent property of the system or by the use of a separate product included as a part of the rated system or device, and designed to perform this function.

2.22 SMOKE-STOPPING AT SMOKE PARTITIONS

- A. Through-penetration smoke-stopping: Any system complying with the requirements for through-penetration firestopping in fire-rated construction is acceptable, provided that the system includes the specified smoke seal or will provide a smoke seal. The length of time of the fire resistance may be disregarded.

2.70 ACCESSORIES

- A. Fill, void or cavity materials and forming materials: Classified for firestopping use, or included in a rated firestopping assembly, by a rating agency.

PART 3 - EXECUTION

3.02 EXAMINATION

- A. Verification of conditions: Examine areas and conditions under which work is to be performed and identify conditions detrimental to proper or timely completion.
 - 1. Verify barrier penetrations are properly sized and in suitable condition for application of materials.
 - 2. Do not proceed until unsatisfactory conditions have been corrected.

3.05 PREPARATION

- A. Clean surfaces to be in contact with penetration seal materials, of dirt, grease, oil, loose materials, rust, or other substances that may affect proper fitting, adhesion, or the required fire resistance.

3.20 INSTALLATION

- A. Provide firestop devices or assemblies for every opening and penetration in floors or fire-rated construction.
- B. Install penetration seal materials in accordance with printed instructions of the rating agency and in accordance with manufacturer's instruction.
- C. Ensure an effective smoke barrier in each sealed penetration. Install smoke stopping as specified for firestopping.
- D. Protect materials from damage on surfaces subject to traffic.

- E. Where large openings are created in walls or floors to permit installation of pipes, ducts, or other items, close unused portions of opening with firestopping material tested for the application.

3.60 FIELD QUALITY CONTROL

- A. Examine penetration seals to ensure proper installation before concealing or enclosing them.
- B. Keep areas of work accessible until inspection and acceptance by applicable authorities.
- C. Before substantial completion, patch and repair firestopping cut or penetrated by other construction work.

3.70 ADJUSTING AND CLEANING

- A. Clean up spills of liquid components.
- B. Neatly cut and trim materials as required.
- C. Remove equipment, materials and debris, leaving area in undamaged, clean condition.

END OF SECTION 230507

SECTION 230508 - HVAC PIPING SPECIALTIES

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Specialties for piping systems.

1.14 RELATED SECTIONS

- A. Piping: Sections 231123 and 232113.
- B. Access doors: Section 230503.
- C. Expansion tanks and air separators: Section 230509.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: For each specialty included in the work. Include rated capacities of selected equipment and manufacturer's installation instructions where applicable. Indicate materials, finishes, dimensions, required clearances, methods of assembly of components; and piping and wiring connections.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Flexible connections, NPS 2.5 through 12:
 - 1. Amber/Booth
 - 2. Dunlop, Inc.
 - 3. Garlock Mechanical Packing Division
 - 4. Keflex (Flex-Weld Inc.)
 - 5. Mason Industries, Inc.
 - 6. Metraflex
 - 7. US Hose Corporation/Senior Flexonics
- B. Gaskets:
 - 1. Garlock Mechanical Packing Division
 - 2. Manville
- C. Dielectric nipples:
 - 1. Anvil International
 - 2. Elster Perfection
 - 3. Precision Plumbing Products, Inc.
 - 4. Sioux Chief Manufacturing Company, Inc.
 - 5. Victaulic Company of America
- D. Water strainers:

1. Keckley
2. Mueller Steam Specialty
3. Spirax Sarco Inc.
4. Tate Andale, Inc. "Guardian"
5. Watts Industries, Inc.

E. High-capacity automatic air vents:

1. Amtrol Inc.
2. Hoffman Specialty Div. of ITT Industries
3. Spirax Sarco Inc.
4. Spirotherm, Inc.
5. Taco, Inc.

F. Automatic air vents:

1. Hoffman Specialty Div. of ITT Industries
2. ITT Bell and Gossett
3. Spirax Sarco Inc.
4. Spirotherm, Inc.
5. Taco Inc.

G. Manual air vents:

1. ITT Bell and Gossett
2. Taco, Inc.

H. Water solenoid valve:

1. Automatic Switch Company (ASCO)

I. Water pressure reducing valves:

1. Spence Engineering Company Inc.
2. Watts Industries Inc.

J. Chemical feeder:

1. Neptune Chemical Pump Company
2. Vulcan Laboratories Inc.

2.21 FLEXIBLE CONNECTIONS, WATER

- A. Flexible connections NPS 1.5 through 12 (DN 40 through 300) for pumps only: Equal to Mason Industries, Inc. Type SFEJ. Units shall have Class 150 flanged ends with multi-layered kevlar tire cord fabric reinforced with peroxide cured EPDM cover, liner and fabric frictioning. Connectors shall be installed with control rods designed with 1/2 inch (12 mm) thick neoprene washer bushings large enough in diameter to withstand the thrust at 1000 psi (70 kg/cm²) maximum on the washer area. Bursting pressure shall be a minimum of three times Operating Pressures. Allowable movements and pressures shall be in accordance with the following:

Pipe Size NPS (DN)	Length Face to Face Inches (mm)	Axial Compression Inches (mm)	Axial Elongation Inches (mm)	Transverse Movement Inches (mm)	Angular Deflection Degrees (Rad)	Operating Pressures Psi (Bar) at Operating Temperatures 170F(77C) 250F(121C)	
						250 (17)	215 (14)
1.5 (40)	4.0 (102)	0.625 (16)	0.5 (12)	0.375 (9.5)	21 (0.37)	250 (17)	215 (14)
2 (50)					20 (0.35)		
2.5 (65)					19 (0.33)		
3 (75)					18 (0.31)		
4 (100)					17 (0.30)		
5 (125)					16 (0.28)		
6 (150)	6.0 (150)	1 (25)	0.625 (16)	0.625 (16)	15 (0.26)		
8 (200)					14 (0.24)		
10 (250)					13 (0.23)		
12 (300)					12 (0.21)		

- B. Flexible connections NPS 2 (DN 50) and smaller: Equal to Senior Flexonics Series BSN, stainless steel with threaded ends in steel pipe and Series BRC, bronze with solder ends in copper pipe.
- C. Flexible connections NPS 2.5 through 12 (DN 65 through 300): Equal to Metraflex Company Type MLP. Units shall have 150 psi flanged ends with corrugated Type 321 stainless-steel inner tube and stainless-steel wire braid outer shield.

2.24 GASKETS, UNIONS, AND DIELECTRIC NIPPLES

- A. Gaskets for flanged joints: Cross-laminated long fiber composition suitable for service, temperature, pressure and liquid with which they come in contact.
- B. Unions NPS 2 (DN 50) and smaller: Malleable iron, Class 150, ASME B16.39, equal to Anvil International with ground bronze seats, or soldered type brass unions of equal quality.
- C. Dielectric nipples:
 1. General: Completely isolate dissimilar metals so that electric current is below 1 percent of the galvanic current which would exist with metal-to-metal contact. Gaskets approved for the medium carried by the piping system.
 2. Dielectric nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain or threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 degrees F (107 degrees C).
 3. Grooved piping: "Dielectric Waterway Fittings" equal to Victaulic Co. "Clearflow" steel threaded ends or thread to Victaulic groove with opaque, high-temperature thermoplastic copolymer liner designed for use at temperatures up to 225 degrees F (107 degrees C) and pressure up to 300 psi (2068 kPa). Complete with ring groove to lock steel casing to plastic liner.

2.25 WATER SPECIALTIES

- A. Y-type strainers:
1. Equal to Spirax Sarco Model IT threaded or Model CI flanged.
 2. For use in copper piping: Spirax Sarco Model BT threaded.
 3. Screens in Y-type strainers: Stainless-steel having maximum 0.045-inch (1.2-mm) perforations.
- B. High-capacity automatic air vent: For releasing air from hot or cold water lines. Float-operated type with minimum 7 cfm (3.3 L/s) capacity.
1. Materials: Cast-iron body and cover; stainless-steel valve pin and seat, and float; gasket conforming to ASTM F 104; high-strength steel cap screws.
 2. Operating limits: Maximum pressure 250 psig (1725 kPa); maximum temperature 300 degrees F (149 degrees C); hydrostatic pressure to 350 psig (2415 kPa).
- C. Automatic air vent: Water vent designed for use on high pressure hot or cold water mains. Includes safety drain connection for discharging moisture entrained in the vented air. Tapped at top for 1/8-inch IPS (DN 6) built-in check valve.
1. Materials: Cast brass body.
 2. Operating limits: Maximum operating pressure 150 psi (1035 kPa); hydrostatic pressure to 450 psi (3105 kPa).
- D. Manual air vent: 150 psig (1035 kPa) working pressure, 212 degrees F (100 degrees C) maximum operating temperature.
- E. Water solenoid valve: Normally closed type, PTFE seal, 120-V coil, equal to Automatic Switch Co., ASCO 8210 in sizes up to NPS 3 (DN 80).
- F. Pressure relief valves: ASME rated, NB approved, automatic reseating type conforming to ANSI Z21.22.
1. Provide straight pressure type where installed in pipe lines and for protection of coils and cold water vessels.
 2. Provide combination pressure and temperature type where installed for hot water tanks and vessels.
- G. Water pressure-reducing valves NPS 2 (DN 50) and smaller: Equal to Spence Model D-36, high-capacity, directly operated, designed for variable flow rate while maintaining close regulation of the reduced pressure. Construction: Single-seated, opening in the direction of flow, with a soft disc; cast bronze with threaded ends suitable for maximum inlet conditions of 300 psi (2070 kPa) at 160 degrees F (71 degrees C). Provide proper spring for range indicated on the drawings. Valve shall meet ASSE Standard 1003 and MIL-V-18146.
- H. Water pressure-reducing valves NPS 2.5 (DN 65) and larger: Equal to Spence Type D-34, single-seated, packless for dead-end service, flanged, ANSI B16.1 Class 125, sizes as shown on the drawings. The valves shall prevent pressure fluctuations without the use of surge chambers or other cushioning devices. Delivery pressure shall be adjustable within a minimum range of 20 psi (138 kPa).

2.27 CHEMICAL FEEDER

- A. Five gallon capacity, cast-iron or welded-steel body, rated for pressure of 200 psi, complete with capped filling opening, connections, inlet, outlet and drain valves, and accessories, as detailed on the drawings.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Plastic piping specialties are not permitted in HVAC system ceiling plenums or shafts used to convey building HVAC air distribution.

3.21 INSTALLING FLEXIBLE CONNECTIONS

- A. Make connections to base-mounted heating and chilled water pumps and to air-handling units with flexible connections, unless coils in air-handling units are otherwise isolated. Flexible connections may also be used in connections to other equipment to provide for proper alignment of piping with connection flange on equipment. Piping on house side of flexible connections shall be securely anchored.

3.23 INSTALLING GASKETS, FITTINGS, AND DIELECTRIC NIPPLES

- A. Gaskets shall be installed in accordance with manufacturer's recommendations.
- B. Pipe connections to fixtures, control valves, equipment and appliances shall be provided with unions or flanges so that the units may be disconnected and replaced without damage to the pipe.
- C. Provide dielectric nipples between copper and steel piping NPS 0.5 through 2.5 (DN 15 through 65).

3.24 INSTALLING WATER SPECIALTIES

- A. Provide specialties for each piping system and for heat transfer elements, as indicated.
- B. Install valves, Y-type strainers, balancing fittings, vacuum breakers, and appurtenances for unit heaters, heating and cooling coils, and heating and cooling elements.
- C. Automatic fill for the hydronic systems shall be as diagramed on the drawings. The pressure-reducing valves and pressure-relief valves shall be line size and adjusted to the pressures indicated on the drawings.
- D. In hydronic systems, provide automatic air vents where indicated and at each high point in piping. Provide 0.375-inch (DN 10) copper tubing from each automatic vent to discharge into main relief lines which discharge into nearest service tank or floor drain. Provide high-capacity type near expansion tank or air separation tank and where indicated. Install manual air vents at each terminal unit.
- E. Install relief valves for devices where required by governing codes. Relief valve discharge shall be piped as indicated or to the nearest floor drain or to within six inches of the floor beside unit.

3.26 INSTALLING CHEMICAL FEEDER

- A. Install on steel angle supports, complete with connections and accessories, as shown on the drawings. Assure that cap is in place and operable.

END OF SECTION 230508

SECTION 230509 - HVAC EXPANSION SYSTEM

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Precharged bladder-type expansion tank and tangential air separator with vent.

1.14 RELATED SECTIONS

- A. Piping: Section 232113.
- B. Supports: Section 230529.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: Each type of expansion system or tank, including each relief and air separation device and all accessories.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified and scheduled products, or comparable products by one of the following:

- 1. Expansion tanks:
 - a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell and Gossett Domestic Pump Div of ITT
 - d. Taco
 - e. Wessels
- 2. Tangential air separators:
 - a. Amtrol, Inc.
 - b. Bell and Gossett Domestic Pump Div of ITT
 - c. Patterson
 - d. Taco

2.31 BLADDER-TYPE EXPANSION TANK

- A. Pressurized bladder-type tank, Taco CA or CBX model number scheduled on the drawings, containing impermeable bladder which separates the air cushion from the system water. Operating temperature: 240 degrees F maximum. Precharge to system fill pressure.
- B. Shell: Welded steel, constructed, tested and stamped in accordance with ASME BPV for Unfired Pressure Vessels for a working pressure of 125 psi (860 kPa), Lined with protective coating.
- C. Bladder: Butyl rubber, flexible but not stretchable under working conditions, removable for inspection.

- D. Size and capacity: Shown on the drawings.
- E. Supports: For horizontal or vertical support on concrete equipment foundation, as diagramed on the drawings.

2.34 TANGENTIAL AIR SEPARATOR

- A. Air separator: Amtrol, Bell & Gossett, or Taco tangential type, designed to eliminate free and entrained air from the system.
- B. Construction: Welded black steel, ASME constructed and labeled for 125 psig (860 kPa) working pressure.
 - 1. Connections:
 - a. NPS 2.5 (DN 65) and larger: Flanged.
 - 2. Air-removing element: Perforated stainless-steel air collector tube.
 - 3. Size: Line size unless otherwise noted on the drawings.

2.36 AUTOMATIC AIR VENT

- A. As specified in Section 230508, HVAC Piping Specialties. Float type vent, size and capacity recommended by manufacturer for tank and system.

PART 3 - EXECUTION

3.21 INSTALLING EXPANSION TANKS

- A. Follow manufacturer's instructions and recommendations.
- B. Install piping, air separation apparatus, and vents as diagramed on drawings.
- C. Install supports as shown on drawings.

3.22 INSTALLING AIR SEPARATOR

- A. Suspend from overhead hanger.
- B. Provide transition fittings if required to match size of pipe and size of air separator connection.
- C. Provide automatic air vent and install drain pipes between vent and floor drain.

3.75 CLEANING

- A. Remove and clean air separator air-removing element after 24 hours operation, and after 30 days operation.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 230500, provide operating instructions.

END OF SECTION 230509

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Unless otherwise specified in a particular section or required for a particular application, motors shall conform to the following requirements, whether factory-installed or field-installed.

1.13 PRODUCT FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Motor capacitors: Section 260521, Wiring Connections.

1.14 RELATED WORK SPECIFIED ELSEWHERE

- A. Pumps: Section 232123.
- B. Chillers: Section 236419.
- C. Air-handling units: Section 237322.
- D. Air-conditioning units: Section 238127.
- E. Energy recovery and dedicated outdoor air units: Section 237200.
- F. Fans: Section 233400.
- G. Unit heaters: Section 238239.
- H. Fan-coil units: Section 238219.
- I. Variable frequency drives: Section 262923.
- J. Variable refrigerant system: Section 238128.
- K. Packaged rooftop unit: Section 237413.
- L. Condensing unit: Section 236313.

1.20 REFERENCES

- A. NEMA MG 1: Motors and Generators.
- B. NEMA MG 10: Energy Management Guide for Selection and Use of Polyphase Motors.
- C. NEMA MG 11: Energy Management Guide for Selection and Use of Single-Phase Motors.
- D. UL 508: Industrial Control Equipment.

1.21 DEFINITIONS

- A. Energy efficient motor: Motor meeting the nominal and minimum efficiency levels listed for its horsepower and speed in Table 12-10 of NEMA MG 1.

- B. Nominal efficiency: Efficiency as defined in Table 12-8, Efficiency Levels, in NEMA MG 1, and identified on the motor nameplate.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data:
 - 1. Motors and drives not provided with equipment: Show nameplate data and ratings; characteristics; mounting arrangements; size and location of winding termination lugs, conduit entry, and grounding lugs, and coatings.
 - 2. Motor capacitors.
- C. Wiring diagrams required for the proper installation of mechanical equipment.
- D. Submit product data which verifies compliance with ASHRAE 90.1 or provide certified performance ratings by a qualified independent testing agency.
- E. Certifications:
 - 1. Actual motor power factor for each motor, certified test results for each motor proposed for use on this project.
 - 2. Field test showing corrected power factor, if required.
 - 3. Motors controlled by variable frequency controllers: Certification that motor meets specified requirements.

1.40 QUALITY ASSURANCE

- A. Actual motor power factor shall be tested and certified by an independent testing laboratory.
- B. Where power factor is field tested as required in "Power Factor" in Part 2 below, specialist performing tests shall be acceptable to the local authorities having jurisdiction.
- C. UL label and local testing (if required): As specified in Section 230500, Common Work Results for HVAC.
- D. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.

1.44 REGULATORY REQUIREMENTS

- A. Motors shall conform to the requirements of NEMA MG1 and applicable portions of the National Electric Code (NEC, NFPA 70).

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Motors:
 - 1. Baldor Electric Co.
 - 2. Marathon
 - 3. Rockwell
 - 4. Siemens

5. A.O. Smith
6. Toshiba International

B. Motor capacitors:

1. ABB Power Distribution
2. Commonwealth Sprague
3. General Electric

2.20 BASIC MOTOR REQUIREMENTS

- A. Capacity: Each motor shall have sufficient capacity and torque to start, accelerate, and operate the machine it drives without exceeding the motor nameplate rating at the speed specified, or at any speed and load which may be obtained by the drive actually furnished.
- B. Starting: Each automatically controlled motor shall be capable of starting as frequently as the control sequence may demand. Motors not automatically controlled shall be capable of making no fewer than 4 starts per hour.
- C. Loads: Belt-connected motors shall be equipped with shafts and bearings designed to withstand both the normal connected loads of the drive furnished, and momentary loads imposed during acceleration.
- D. Ratings: Motors shall be rated for continuous duty at 100 percent of rated capacity, and temperature rise shall be based on ambient temperature of 40 degrees C.
- E. Phase: Unless otherwise indicated, motors one-half horsepower and larger shall be polyphase and motors smaller than one-half horsepower shall be single-phase motors.
- F. Motor construction:
 1. Motors for fans, air handling units, and pumps, unless specified otherwise in the equipment section, shall be open drip-proof NEMA design B construction.
 2. Motors where indicated or specified, motors mounted outdoors, shall be totally enclosed, fan-cooled (TEFC) extra severe-duty. Motors outdoors inside weather-tight enclosures may be open drip-proof type.
- G. Efficiency: The term "energy efficient" is defined in the article "Definitions" in Part 1 above.
 1. Single-phase motors, alternating-current fractional horsepower, rated 1/20 to 1 horsepower, 250 volts or less: NEMA MG 11, types and efficiencies selected for their applications.
 2. Polyphase motors, medium alternating-current, squirrel-cage, 1 to 500 horsepower, 600 volts or less: NEMA MG 10, energy-efficient types selected for their application. Nominal full-load efficiencies shall meet or exceed ratings of Table 12-10 of NEMA MG 1.
 3. Motors for packaged hermetic and semi-hermetic refrigeration compressors need not comply with these efficiency requirements but they shall comply with the requirements indicated for power factor and power consumption.

2.21 SINGLE-PHASE MOTORS

- A. Permanent split-capacitor or split-phase type.
- B. Bearings: Sealed, prelubricated ball-bearing type.

2.22 POLYPHASE MOTORS

- A. NEMA MG1 Design B.
- B. Stator: Copper windings.
- C. Rotor: Squirrel cage.
- D. Bearings: Doubly shielded, prelubricated ball bearings suitable for radial and thrust loading of connected equipment.
- E. Temperature rise shall not exceed insulation rating.
- F. Insulation: Class F.
- G. Motors used with inrush controllers: Match wiring requirements for indicated controller with required motor leads brought to motor terminal box to suit control method.
- H. Horsepower/frame relationship: NEMA Standard for T frame motors.
- I. Motor frame and endshields: Cast iron.
- J. Conduit box: Either steel or aluminum, diagonally split and rotatable in 90-degree increments, with grounding provision.
- K. Finishes:
 - 1. External hardware: Plated to resist corrosion.
 - 2. External paint: Industrial enamel.
- L. Nameplates: Stainless steel or aluminum, and stamped in accordance with NEMA MG1. Nameplate information shall include the nominal efficiency value in accordance with NEMA MG1 and the manufacturer's minimum guaranteed efficiency value.

2.23 ELECTRONICALLY COMMUTATED MOTOR (ECM)

- A. Brushless direct current (DC) variable speed motor supplied with alternating current, with a permanent magnet with near zero rotor losses, permanently-lubricated ball bearings, electronic commutation, designed for synchronous rotation, and at least 70% efficient at all operating speeds.
- B. As a minimum, the motor shall include the following features:
 - 1. Integrated controller / inverter that operates the wound stator and senses rotor position to electronically commutate the stator.
 - 2. Thermal overload protection.
 - 3. Built-in soft start and soft speed change ramps.
 - 4. Inductors to minimize harmonic distortion and line noise.
 - 5. Designed to overcome reverse rotation without affecting life expectancy.
 - 6. Motor speed shall be controllable down to 20 percent of full speed. Speed shall be controlled by either a potentiometer with manual adjustment on the motor or by a 0-10Vdc analog signal from a remote source, as required by other sections of Division 23 specifications.
 - 7. Software for motor control shall be as indicated or described in other Division 23 specifications.

2.24 TOTALLY ENCLOSED FAN-COOLED (TEFC) MOTORS

- A. Polyphase motors with the following additional requirements:
1. TEFC construction for severe environment.
 2. Ventilating fans: Made of corrosion-resistant, non-sparking material.
 3. Conduit box: Heavy-wall cast construction, gasketed with a lead gasket between box and motor frame.
 4. Motor shaft shall be provided with an external slinger on the drive end.
 5. Rotor and stator air-gap surfaces coated to prevent corrosion.
 6. Finish: At least two coats of catalyzed epoxy enamel.

2.25 MOTORS CONTROLLED BY VARIABLE FREQUENCY DRIVES

- A. Specifically constructed and warranted by the manufacturer to meet the voltage requirements of NEMA MG 1, Part 31.4.4.2.
- B. Temperature rise: Match rating for Class B insulation.
- C. Insulation: Class B or F (TEFC), or Class F (ODP).
- D. Bearing protection: Conductive shaft grounding ring, equal to Aegis SGR by Electro Static Technology, to transmit induced current from shaft to motor frame without harming bearings.

2.26 POWER FACTOR

- A. Power factor for three-phase motors 10 HP and larger and packaged equipment systems totaling 10 HP and larger as noted below shall be not less than 90 percent at full rated load. Test, certify, and submit certified reports for each motor as required in "Submittals" and "Quality Assurance" in Part 1 above.
1. Should the Contractor propose to provide motors with less than 90 percent power factor, provide power-factor-correcting, automatically discharging type motor capacitors. The corrected power factor of the motor-capacitor combination shall be equal to or greater than 90 percent. Submit certified test results.
 2. Motor capacitor: Designed for installation at the load side of motor starters; insulated, impregnated component unit completely enclosed in a grounded steel case with welded and ground seams. Where installed on outdoor equipment, case shall be weatherproof. Provide each unit with a flexible cable for connection to the starter or motor terminals. The capacitor shall be suitable for use in areas with ambient temperatures ranging from minus 10 degrees F to 115 degrees F.
- B. Where motors totaling 10 HP and larger are part of packaged equipment system, such as packaged air-conditioning unit or air-conditioning condensing unit, the overall power factor for the entire system package shall be no less than 90 percent. Provide capacitors and appurtenances required to accomplish this power factor as part of the packaged equipment, or furnish separately and wire as work of equipment installation. Capacitors shall be stepped, deenergized, or cycled when the unit is deenergized or the load is varied, to maintain 90 percent power factor.
1. Capacitors provided as part of packaged equipment: If the installation of the capacitors voids the UL label, unit shall be tested. Actual power factor shall be factory-tested and certified test results included in submittals.

2. Capacitors provided separately and wired as work of equipment installation: Unit shall then be field tested to verify actual power factor. Submit field test reports.
 3. Tests shall be performed by an electrical testing specialist and in accordance with NFPA 70 (NEC) testing brochure.
- C. Motors and packaged equipment systems equipped with variable frequency drives shall not receive power factor correcting capacitors.

2.27 MOTOR DRIVES

- A. Motors for belt-driven units shall have adjustable variably pitched cast-iron sheaves to allow a 10 percent increase or reduction in speed for units less than 30 HP and fixed sheaves for units 30 HP and larger. Belts shall be sized for minimum 150 percent BHP. Provide OSHA- and MOSHA-approved type belt guards. Include one change in drive sheave for each unit if necessary to obtain required air quantities and static pressure.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Mount direct-connected motors securely and in accurate alignment. The drive shall be free from both angular and parallel misalignment when both motor and driven machine are operating at normal temperatures.
- B. Provide each belt-connected motor with a securely mounted adjustable base to permit installation and adjustment of belts.
- C. Mount capacitors shipped separately beside motor connection box as required. Connect in accordance with the requirements of Division 26, Electrical.
1. Test units at full rated load after the installation of the motor capacitors, and submit reports.
- D. Provide additional drive and belt changes where required to meet requirements of testing and balancing specified in Section 230593, Testing, Adjusting and Balancing.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 230500, provide operating instructions.

END OF SECTION 230513

SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Meters and gages for HVAC systems.

1.14 RELATED SECTIONS

- A. Pipe installation and testing: Section 230500.
- B. Valve tags and charts: Section 230523.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Shop drawings: Meter and gage schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gage.
- C. Product data: For each type of meter, gage, device, and fitting specified.
 - 1. Scale range.
 - 2. Ratings.
 - 3. Calibrated performance curves.
- D. Show flow measurement locations on valve charts specified in Section 230523, General-Duty Valves for HVAC Piping.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Meters and gages:
 - 1. AMETEK; U.S. Gage
 - 2. Ashcroft; Dresser Instrument
 - 3. Miljoco Corporation
 - 4. Taco, Inc.
 - 5. H.O. Trerice Co.
 - 6. Weiss Instruments
 - 7. Weksler; Dresser Instrument
- B. Pressure-temperature connections:
 - 1. Miljoco Corporation
 - 2. Peterson Equipment Company
 - 3. Sisco
 - 4. Texas Fairfax Company
 - 5. H.O. Trerice Co.
 - 6. Utilities Materials and Controls, Inc.
 - 7. Weiss Instruments

2.11 THERMOMETERS

- A. General: Industrial, adjustable angle type, accurate to within plus or minus one percent of range span, baked enamel finish, blue reading organic liquid tube, glass or clear acrylic plastic window, dust and moisture tight.
 - 1. Scale size: 9 inches (230 mm).
 - 2. Graduation: To the scale shown on the drawings or of a scale so that the normal working temperature of the system is near the mid-point of the scale.
 - 3. Case: Cast aluminum.
- B. Pipe-mounted thermometers: Brass well, separable sockets.
 - 1. Where mounted in insulated piping, thermometers shall have six-inch (150-mm) stem length and sockets with 2.5-inch (64-mm) lagging extension necks. Where mounted in uninsulated piping, they shall have 3.5-inch (89-mm) stem lengths and sockets without lagging extension.
 - 2. Where thermometer wells only are required, provide separable socket with 2.5-inch (64-mm) lagging extension, fitted with attached chain and cap.
- C. Duct-mounted thermometers: Perforated aluminum stem, length maximum 24 inches (610 mm) or of length to have end of bulb near center of duct. Provide union flange fitting where stem passes through duct side or unit casing. Provide lagging extension flange on insulated ductwork.

2.12 PRESSURE GAGES

- A. Pressure gages shall be accurate to within plus or minus one percent of range span, silver brazed bronze bourdon-tube system, bronze movement, aluminum dial with white background, black graduations and numerals and adjustable pointer, bottom connected.
 - 1. Dial diameter: 6 inches (150 mm).
 - 2. Those installed adjacent to pumps or in pulsating locations shall be provided with pulsating dampeners or snubbers.
 - 3. Case: Cast aluminum or glass filled nylon.
- B. Graduation: To the scale shown on drawings, or so pointer is nearly straight up at system normal working pressure.
- C. Gages shall be straight pressure type, except gages on suction side of pumps and inlet side of suction strainers shall be compound type.
- D. Gage cock (pressure gage isolation valve):
 - 1. Needle valve: Brass bar stock needle valve, equal to Weksler No. BBV4.
 - 2. Ball valve: Bronze, three-piece body, full port, with Type 316 stainless steel trim, 150 psi (1034 kPa) saturated steam, 600 psi (4137 kPa) non-shock cold water, oil, or gas, equal to Nibco 595.
- E. Pressure gage for fuel gas service: ASME B40.1, Grade A phosphor-bronze Bourdon-tube pressure gage, with bottom connection, designed for pressure 10 psi (69 kPa) and less with 1/10 of 1 psi increments; equal to Terice No. 760B.
 - 1. Case: Drawn steel or brass, with 2.5-inch (64-mm) diameter glass lens.
 - 2. Connector: Brass, 0.25-inch (DN 8) NPS.
 - 3. Scale: White coated aluminum, with black graduations and markings.

4. Accuracy: Plus or minus 1.6 percent of range.

2.13 COMBINATION PRESSURE-TEMPERATURE CONNECTIONS

- A. Combination pressure-temperature connections: Equal to UMAC Universal Lancaster Test Plugs, Peterson "Pete's Plug," Sisco, Fairfax P/T Plugs, H.O. Trerice test plugs, or Miljoco test plugs. Plugs shall have self-closing valve which will operate at a temperature up to 300 degrees F (149 degrees C). Body and cap shall be brass, and shall receive either a temperature or pressure probe. Provide with a kit including gages and thermometers in a protective case.

2.15 VENTURI FLOWMETERS

- A. Basis-of design product: Subject to compliance with requirements, provide Preso Meters or comparable product by one of the following:
 1. Armstrong Pumps, Inc.
 2. Badger Meter, Inc.; Industrial Div.
 3. Flow Design, Inc.
 4. Gerand Engineering.
 5. Hyspan Precision products, Inc.
 6. Preso Meters
- B. Description: Differential-pressure design for installation in piping; with calibrated flow-measuring element, separate flowmeter, hose or tubing, valves and extension; fittings, and conversion chart compatible with flow-measuring element, and protective case.
- C. NPS 0.5 through 1.5 (DN 15 through 40): Provide a venturi flow meter of the "Low Pressure Loss" design, differential pressure type, equal to Preso Meters V-Brass Series.
 1. Maximum pressure: 400 psig (2756 kPa).
 2. Maximum temperature: 250 degrees F (120 degrees C).
 3. Material: Brass, ASTM B16.
 4. Connections: Sweat ends.
- D. NPS 2 (DN 50) and larger: Provide a flow element of the metering design, differential pressure type, equal to Preso Meters CV Series.
 1. Venturi inlet: Cylindrical with a pressure sensing tap and diameter equal to the incoming pipe section.
 2. Precise convergence section.
 3. Venturi throat: Pressure sensing tap.
 4. Exit cone: Precise angle to prevent a permanent pressure loss not to exceed 15 percent of the generated differential pressure.
 5. Maximum pressure: 300 psig (2070 kPa).
 6. Maximum temperature: 250 degrees F (120 degrees C).
 7. Accuracy: Plus or minus 2 percent.
 8. Repeatability: Plus or minus 0.2 percent.
 9. Turndown: 10:1.
 10. Material: Carbon steel with stainless-steel ID tag.
 11. Mounting: 150 pound flange, ANSI 16.5.
- E. Instrument valves and connections: Brass ball valves with extensions, 1/8 inch by 1/4 inch SAE.

F. Permanent indicators: Suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- (150-mm-) diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.

1. Scale: Gallons per minute (Liters per second).
2. Accuracy: Plus or minus 1 percent between 20 and 80 percent of range.

G. Operating instructions: Include complete instructions with each flowmeter.

2.20 ELECTROMAGNETIC DDC FLOW METER FOR CHILLED/HEATING WATER SYSTEM

A. Inline insertion electromagnetic flow-detecting meter coupled to a wall-mounted remote meter controller, equal to Onicon F-3100 Series. Fully digital measurements for volumetric flow, totalized flow, and flow velocity via correlation transit-time mode. Suitable for chilled/heating water conditions and pipe sizes and wall thicknesses as shown on the drawings.

B. Construction: Carbon-steel body with AISI Type 304 stainless-steel internal flow tube and ANSI Class 150 raised-faced flanged end connections.

C. Controller: NEMA 250 Type 4X reinforced nylon enclosure, 64- by 128-pixel backlit 2-line alphanumeric LCD graphic display. Complete with cabling to interconnect meters, transmitters, and temperature sensors to controllers.

D. Process liquids:

1. Heat pump loop water from 40 to 100 degrees F (4.4 to 37.8 degrees C) and 0 to 200 psig (0 to 1390 kPa).

E. Temperature transducer: Clamp-on or wetted surface type equal to GE GS868. Provided in thermowells, multiple-wire RTD platinum transducer compatible with flow meter, its controller, and liquid operating conditions.

1. Accuracy: Plus or minus 2 percent.
2. Output: Conditioned pulse and analog 4 to 20 mA current signal.
3. Sizes: NPS 1-1/2 to 14 (DN 40 to 350).

F. Pressure transmitters: Wetted surface type equal to GE GS868. Provided in thermowells, multiple-wire transmitter compatible with flow meter, its controller, and liquid operating conditions.

1. Accuracy: Plus or minus 2 percent.
2. Output: Conditioned pulse and analog 4 to 20 mA current signal.
3. Sizes: NPS 1-1/2 to 14 (DN 40 to 350).

G. Input-outputs: Meters capable of providing the following flow and energy measurements:

1. Loop water temperature, conductivity, and pressure.
2. Loop water flow in feet per second (m/s), BTU per hour (kW/hour), and gallons per minute (l/s).
3. Totalized loop water flow in the above units.

H. Velocity accuracy: Plus or minus 0.4 percent of range from 3.3 to 33 feet/second (1.0 to 10.1 m/s).

- I. Velocity range: Minus 40 to 40 feet/second (minus 12.2 to 12.2 m/s).
- J. Communication: Provide BACnet communications card for DCS data transfer.
- K. Power: 120 Vac, single phase, 60 Hertz, 35 mA maximum.
- L. Output: Conditioned pulse and analog 4 to 20 mA current signals.
- M. Sizes: NPS 1 (DN 25) for maximum 85 gpm (5.4 l/s) to NPS 12 (DN 300) for maximum 11,000 gpm (694 l/s).

PART 3 - EXECUTION

3.21 INSTALLING THERMOMETERS

- A. Pipe line thermometers shall be installed as indicated on the drawings.
- B. Duct thermometers for air handling units shall be located as follows, except thermometers are not required if air system is not ducted:
 - 1. Draw-through units: (4 per unit)
 - a. OA duct: rigid bulb, minus 20 to plus 130 degrees F (minus 28.9 to plus 54.4 degrees C).
 - b. RA duct: rigid bulb, plus 30 to 180 degrees F (minus 1.1 to plus 82.2 degrees C).
 - c. Discharge duct: rigid bulb, plus 30 to 180 degrees F (minus 1.1 to plus 82.2 degrees C).
 - d. Mixed air plenum: rigid bulb, plus 30 to 180 degrees F (minus 1.1 to plus 82.2 degrees C) (on discharge side of filter).
 - 2. Rooftop Units:
 - a. Discharge duct: rigid bulb, plus 30 to plus 180 degrees F (minus 1.1 to plus 82.2 degrees C) located below roof. Provide small ceiling identification tags as specified in Section 23 0500 where thermometers are above an accessible, suspended ceiling. Attach tags adjacent to ceiling panel to be removed.
- C. Units made up of fan section, filter section, and duct-mounted coils shall be provided with thermometers the same as draw-through units.
- D. Furnish and deliver to Owner at final inspection, three additional pipe line thermometers as above specified, with 6-inch (152-mm) stem lengths, for use in the thermometer wells. Ranges shall be minus 40 to plus 110 degrees F (minus 40 to 43.3 degrees C.); 20 to 120 degrees F (minus 6.7 to 48.9 degrees C.), and 50 to 550 degrees F (10 to 287.8 degrees C).

3.22 INSTALLING PRESSURE GAGES

- A. Each gage connection shall have a gage cock. Connections to pipe lines shall be 0.5 inch (DN 15), with 0.5 inch (DN 15) by 0.25 inch (DN 8) reducer for valve, the assembly of sufficient length to clear insulation.
- B. Where gage cocks only are called for on drawings, provide the 0.5-inch (DN 15) connections to pipe line with reducer and the gage cock.
- C. Provide one compound and one straight pressure gage of appropriate scale to Owner at final inspection.

3.23 INSTALLING COMBINATION PRESSURE-TEMPERATURE CONNECTIONS

- A. Option: Provide combination pressure-temperature connections, complete with kits, where thermometer wells or gage cocks only are called for on the drawings.

3.24 INSTALLING FLOW METERS

- A. Install a flow meter fitting or permanently installed meter as indicated on drawings. When locating the fittings, assure that sufficient straight run of pipe is provided both upstream and downstream from fittings as recommended by the manufacturer for accurate readings. Size of fittings shall be same as pipe size.
 - 1. Provide each fitting with an identification tag as specified for valve tags, giving station identification number, pipe size, meter scale and required flow in gpm (l/s).
 - 2. Show flow meter locations on valve charts specified in Section 230523.
- B. For DDC flow meters, provide connection to Building Automation System.

END OF SECTION 230519

SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Valves for various piping systems.
- B. Chainwheel operators.

1.14 RELATED SECTIONS

- A. Piping installation and testing: Section 230500.
- B. Piping systems: Section 232113.
- C. Automatically operating valves: Section 230508.
- D. Access doors: Section 230503.
- E. Valves for fuel gas system: Section 231123.

1.20 REFERENCES

- A. ASME B16.10: Face-to-Face and End-to-End Dimensions of Valves.
- B. ASME B16.34: Valves - Flanged, Threaded, and Welding End.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: For each type of valve. Include body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions.
- C. Maintenance data: For inclusion in operation and maintenance manual specified in Division 01 and Section 230101. Include manufacturer's instructions for adjusting, servicing, disassembling, and repairing.
- D. Valve charts: Furnish valve charts typed on 8.5 by 11-inch (216 by 279-mm) bond paper, showing locations of all manual and automatic control valves, and flow meters. Include:
 - 1. Number
 - 2. Location
 - 3. Service
 - 4. Function
 - 5. Area served
- E. Valve numbering system shall be approved by the Owner prior to final submittal. Place one copy of approved chart in a plastic envelope and mount on wall where directed. Provide another copy for each of the Operating and Maintenance Manuals.

1.40 QUALITY ASSURANCE

- A. Ferrous valves shall conform to ASME B16.10 and B16.34 for dimension and design criteria.
- B. Copper alloy valves (brass and bronze) shall have no more than 15 percent zinc in the alloy.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Ball valves: Subject to compliance with requirements, provide the specified NIBCO valve, or comparable product by one of the following:
 - 1. Apollo Valves
 - 2. Milwaukee Valve Co.
 - 3. NIBCO
 - 4. Stockham Valve & Fittings
 - 5. Victaulic Company of America
 - 6. Walworth Co.
 - 7. Watts Regulator Co.
- B. High-performance butterfly valves: Subject to compliance with requirements, provide the specified high performance Bray valve, or comparable product by one of the following:
 - 1. Bray Controls; a division of Bray International, Inc.
 - 2. NIBCO
 - 3. DeZurik
 - 4. Jamesbury; a subsidiary of Metso Corporation
 - 5. Victaulic Company of America.
- C. Check valves: Subject to compliance with requirements, provide the specified NIBCO valve, or comparable product by one of the following:
 - 1. Combination Pump and Valve Co.
 - 2. Mueller Steam Specialty
 - 3. NIBCO
 - 4. Victaulic Company of America
- D. Balancing valves: Subject to compliance with requirements, provide specified venturi ball valve (readable) by Flo-Pac or NuTech Hydronic Specialty Products, or comparable product by one of the following:
 - 1. Flow Design
 - 2. Gerand Engineering
 - 3. Griswold Controls
 - 4. Pro Hydronic Specialties
 - 5. Taco
 - 6. Tour & Andersson
 - 7. For sizes specified to be butterfly valves with memory stop and venturi flow-measuring assembly, include specified high-performance butterfly valve.
- E. Drain valves: Subject to compliance with requirements, provide the specified NIBCO valve, or comparable product by one of the following:

1. Apollo Valves
2. Milwaukee Valve Co.
3. NIBCO
4. Stockham Valve & Fittings
5. Victaulic Company of America
6. Walworth Co.
7. Watts Regulator Co.

2.20 VALVES

A. Ball valves:

1. Valves NPS 2 (DN 50) and smaller: Class 150 SWP, bronze, two-piece body, full port, TFE seats and seals, stainless-steel ball and stem. Extension handle for use in insulated piping. NIBCO T-585-70-66 or S-585-70-66, threaded or soldered ends.

B. High performance butterfly valves, NPS 2.5 (DN 65) and larger: High-performance lug body.

1. Class 150 suitable for use with ASME B16.5 Class 150 flanges.
2. Bidirectional service at 200 psi (1379 kPa) and maintain bubble-tight rating according to ANSI/FCI 70-2 Class VI or API 598 shutoff against 270 psi operating at cold working temperatures.
3. Body: Carbon steel, for flanged connection with alignment bolts, holes, or guides.
4. Seat: Single-piece, reinforced, PTFE, suitable for continuous operation at 121 degrees C, field-replaceable.
5. Bearings: Stainless-steel, PTFE-backed, self-lubricating.
6. Stem seals: PTFE.
7. Shaft: Type 316 stainless steel, including shaft seat, retaining ring, and fasteners. Double offset shall reduce torque on seat.
8. Disk: Type 316 stainless steel.
9. Operator:
 - a. NPS 6 (DN 150) and smaller: Ten-position leverlock handle.
 - b. NPS 8 to 10 (DN 200 to 250): Gear operator (30 to 1 gear reduction).
10. Provide 2-inch minimum extension handle where required in insulated piping.
11. Where used for balancing, provide memory stop.

C. Center-guided, spring-loaded silent-action type check valves:

1. Valves NPS 2 (DN 50) and smaller: Class 125, bronze body, Teflon disk, Teflon seat ring, stainless-steel stem and spring, NIBCO Fig. S-480Y or T-480-Y, threaded or soldered ends.
2. Valves NPS 2.5 (DN 65) through NPS 10 (DN 250): Class 125, cast-iron body, bronze trim, stainless-steel spring, NIBCO Fig. W-910, wafer style.
3. Valves NPS 12 (DN 300) and larger: Class 125, cast-iron body, stainless-steel spring, NIBCO Fig. F-910, flanged.

D. Swing check valves:

1. Valves NPS 2 (DN 50) and smaller: Class 125, bronze, PTFE seat, renewable disks, Y pattern, horizontal swing, NIBCO T-413-Y or S-413-Y, threaded or soldered ends.
2. Valves NPS 2.5 (DN 65) and larger: Class 125, IBBM, bolted bonnet, renewable seat and disk, horizontal swing NIBCO Fig. F-918-B, flanged ends.

E. Balancing valves:

1. NPS 2 (DN 50) and smaller: Venturi ball valve (readable valve) with threaded or soldered ends, Flo-Pac or Nutech Hydronic Specialty Products Model MB, Taco "Accu-Flo (ACUF)," Gerand "Balvalve-Venturi (BV)," Tour & Andersson STAD Series, Griswold Controls "QuickSet," FlowDesign Model UA or Pro Hydronic Specialties Model CBV.
 - a. Materials: Brass and bronze body, chrome-plated brass ball, PTFE seats and stem packing.
 - b. Ratings: Entire assembly 250 psi, 250 degrees F (1725 kPa, 121 degrees C).
 - c. Flow element: Low-loss, high-signal venturi section with schrader or quick-connect pressure-ports, reliability one to ten and accuracy 2 percent.
 - d. Stem: Blowout-proof.
 - e. Memory stop: On valve section, adjustable, with extended handle.
 - f. Bellows type meter gage kit with case, provide one for use on the entire project.
2. NPS 2.5 (DN 65) and larger: High-performance butterfly valve with memory stop coupled with a venturi flow-measuring assembly.
 - a. Venturi type flow element: Low-loss, high-signal venturi with schrader or quick-connect pressure ports, accuracy plus or minus 3 percent FS.
 - b. Provide Owner, one bellows-type meter gage kit with case for use on the entire project.

2.21 DRAIN VALVES

- A. Two-piece full-port ball valve, NPS 0.75 (DN 20), 600 psi (4137 kPa) CWP, 400 deg F (204 deg C) maximum operating temperature, bronze body, PTFE seats and seals, chrome-plated brass ball, threaded hose outlet with brass cap and chain, lever handle. Provide extension handle where used in insulated piping. NIBCO T-585-70-HC or S-585-70-HC; threaded or soldered inlet.
 1. Provide a removable handle where valve is accessible to the general public.

2.70 CHAINWHEEL OPERATORS

- A. Manufacturers:
 1. Babbitt Steam Specialty Co.
 2. Roto Hammer Industries, Inc.
- B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
 1. Sprocket rim with chain guides: Ductile iron or cast iron, of type and size required for valve. Include zinc coating.
 2. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
 3. Chain: Hot-dip, galvanized steel of size required to fit sprocket rim.
- C. Chain storage canisters: Non-corrosive canisters for storage of overhead chains, allow for chain loop release in a single downward movement.
 1. Canisters: Plastic, safety yellow or orange color, with perforated bottom for drainage and integral release handle, quick-release hooking mechanism and retention lanyard.
 2. Attach to each overhead chain loop with 6 feet minimum clearance below canister.
 3. Equal to Roto Hammer, Model CHAW "Chain Away."

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Install valves to be readily accessible for operation and maintenance, and with ample clearance for turning handles or operators.
- B. For valves in inaccessible locations, provide access doors as specified in a related section.
- C. Identify valves as specified in Section 230500, Common Work Results for HVAC.
 - 1. Provide tags for all valves except stop valves on individual fixtures or equipment where their function is obvious, or where the fixture or equipment is immediately adjacent. Numbers shall correspond to those shown on the Valve Chart. Attach tags to valve shaft.
 - 2. Provide ceiling identification tags where valves are above an accessible suspended ceiling. Number shall correspond to tag number.
- D. Install chainwheel operators on valves NPS 4 (DN 100) and larger and more than 7 feet (2150 mm) above floor. Extend chains to 6 feet (1850 mm) above finished floor elevation.

3.21 INSTALLING SHUTOFF AND BALANCING VALVES

- A. Install shutoff and balancing valves where indicated. Generally, install balancing valves in return lines of heating and cooling coils and elements, and shutoff valves in supply lines.
- B. Shutoff valves for water piping systems shall be as follows:
 - 1. Sizes NPS 2 (DN 50) and smaller: Ball valves.
 - 2. Sizes NPS 2.5 (DN 65) and larger: High-performance butterfly valves.
- C. Balancing valves: Locate valve to provide 5 pipe diameters straight inlet and 2 pipe diameters straight outlet.

3.22 INSTALLING CHECK VALVES

- A. Provide center-guided, spring-loaded silent-action type check valves in pumped lines, lines subject to pump pressure, and vertical lines.

3.24 INSTALLING DRAIN VALVES

- A. Install drain valves, NPS 0.75 (DN 20) or size indicated on the drawings, at every low point of a water system, and where indicated.

END OF SECTION 230523

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Supports for piping systems and equipment.
- B. Equipment foundations.
- C. Pipe guides and anchors.
- D. Accessories.

1.14 RELATED SECTIONS

- A. Vibration control supports: Section 230548.
- B. Duct supports: Section 233113.

1.20 REFERENCES

- A. ASME B31.9: Building Services Piping.
- B. MSS SP-58: Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

1.21 DEFINITIONS

- A. Definitions are from MSS SP-58, "Classification of Piping Systems."
- B. Hot Systems: Maximum operating (service) temperatures 120 degrees F (49 degrees C) and above.
- C. Ambient Systems: Maximum operating temperatures 60 to 119 degrees F (16 to 48 degrees C).
- D. Cold Systems: Maximum operating temperatures 59 degrees F (15 degrees C) and below.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: Provide manufacturer's literature showing compliance with specifications for each type of hanger, manufactured support, guide, and anchor, including fasteners and accessory materials.

1.40 QUALITY ASSURANCE

- A. Hangers, supports, guides, and anchors shall comply with the requirements of:
 - 1. MSS SP-58.
 - 2. ASME B31.9.
- B. Qualifications of welders: As specified in Section 230500, Common Work Results for HVAC.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Hangers

1. Anvil International
2. Carpenter and Paterson, Inc.
3. National Pipe Hanger Corporation
4. PHD Manufacturing, Inc.
5. PHP Systems/Design

B. Support systems

1. Anvil International
2. PHD Manufacturing, Inc.
3. PHP Systems/Design
4. Unistrut
5. Cooper (Refrigerant Piping)

C. Thermal hanger shields

1. Carpenter and Patterson, Inc.
2. Pipe Shields, Inc.
3. Rilco Manufacturing Co., Inc.

D. Pipe guides

1. Adscop
2. Carpenter and Paterson, Inc.
3. Metraflex Company

E. Anchors

1. Carpenter and Paterson, Inc.
2. Metraflex Company

2.10 CONCRETE

- A. Concrete shall be no less than 3000-lb (25,000 kPa) strength.
- B. Reinforcement: 6 by 6 inch (150 by 150 mm) welded steel wire fabric, ASTM A 185.

2.11 GROUT

- A. Non-shrink grout: Premixed, consisting of non-metallic aggregate, cement, and water-reducing and plasticizing agents; capable of developing minimum compressive strength of 7,000 psi (48,000 kPa) in 28 days.
 1. Sonneborn-Rexnord "SonogROUT"
 2. L&M Construction Chemical Company "Crystex"
 3. US Grout Corporation "Five-Star Grout"

2.20 HANGERS AND SUPPORTS

- A. Types are identified by MSS type numbers in the article Installing “Pipe Hangers and Supports” below.
- B. Materials for hangers and clamps:
 - 1. For uninsulated copper pipe: Copper plated.
 - 2. For uninsulated steel pipe and all insulated pipe: Galvanized in crawl spaces, tunnels, or wet areas; galvanized or factory-painted in other areas.
 - 3. For refrigerant piping: Clamp inserts, equal to Cooper “B-Line” armafex clamps, suitable for hanger or channel supports.
- C. Insulating-insert materials and protection shields:
 - 1. Insulation-insert material for cold piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa); or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier. Insert thickness shall match adjacent piping insulation thickness.
 - 2. Insulation-insert material for hot piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa); ASTM C 552, Type II cellular glass with 100-psig (688-kPa); or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength. Insert thickness shall match adjacent piping insulation thickness.
 - 3. Insert and shield shall cover entire circumference of pipe.
 - 4. Insert length: Extend 2 inches (50 mm) beyond shield.
- D. Pipe covering protection saddle: Steel, meeting requirements of MSS SP-58 Type 39, with insulating material located in the space between saddle and pipe.
- E. Hanger rod nuts and washers shall be zinc-plated. Hanger rods shall be solid steel, all threaded, and zinc-plated.
- F. Channel: Slotted cold-rolled steel, equal to Power Engineering Company PS 150 S, 12 gage with 0.406- by 3-inch (10 by 76-mm) slots on 4-inch (102-mm) centers.
- G. Wall- and floor-mounted supports: Structural support system equal to Power Engineering Company “Power Strut.”
- H. Structural shapes: ASTM A 36.
- I. Steel pipe: ASTM A 53, Grade B, Type E (electric resistance welded), Schedule 40, black and galvanized steel.
- J. Threaded rod: MSS SP-58.

2.22 FASTENERS

- A. Fasteners to concrete: Self-drilling type expansion shields or machine bolt drop-in anchors for drilled holes, equal to ITT Phillips Anchors “Red Head.” Fasteners to ceilings shall be vibration and shock resistant. Load applied to fasteners shall not exceed 25 percent of manufacturer’s stated load capacity in 3500 psi (24,000 kPa) concrete.
- B. Fasteners to drywall or cavity wall construction: Equal to ITT Phillips Anchors “Red Head” toggle bolts, with hollow wall drive anchors or nylon anchors as required.

- C. Bolts, nuts, and washers: ASTM A 307, or ASTM A 325 where high strength is required.

2.23 PIPE GUIDES

- A. Pipe alignment guides shall be equal to Carpenter and Paterson Figure 1007 heavy-duty insulating type, consisting of a spider and a housing sleeve, constructed of minimum 0.375-inch-thick (9.5-mm) steel.

2.24 PIPE ANCHORS

- A. Anchors shall be fabricated from structural steel conforming to ASTM A 36 as detailed on the drawings; shall conform to applicable ASME codes; and shall be capable of withstanding the forces imposed by the system on anchor points.
- B. Anchor pipe shoes: Gusseted, equal to Carpenter and Paterson Figure 1120.

2.70 GUY WIRE AND ACCESSORIES

- A. 0.25-inch (6-mm) wire rope, galvanized, construction 7 by 19, minimum 7000 lbs (31150 N) breaking strength (aircraft cable).
- B. Galvanized cable clamps to fit diameter of wire rope.

PART 3 - EXECUTION

3.20 INSTALLING PIPE HANGERS AND SUPPORTS

- A. Types and locations, refer to MSS SP-58:

Type 1: Clevis hanger:

1. Hot Systems NPS 0.5 (DN 15) through NPS 8 (DN 200).
2. Ambient Systems and Cold Systems of all sizes.

Type 8: Riser clamp, steel for steel or cast-iron risers and stacks, copper plated for copper risers and stacks.

Type 10: Copper-plated adjustable swivel ring for uninsulated copper piping NPS 0.5 (DN 15) through NPS 4 (DN 100). Use Type 1 for insulated pipe.

Type 20: Side beam clamp for attaching hanger rods to structural beams. Use proper size clamp to suit beam flange.

Type 23: C clamp for beams with maximum flange thickness of 0.75 inch (19 mm); for use with single pipes NPS 2 (DN 50) and smaller.

Type 40: Pipe-covering protection shield of proper size to fit insulation, between hanger and insulation:

1. Size to fit pipe, between hanger and plastic piping.
2. Include structural insulation insert between protection shield and pipe for piping NPS 2.5 (DN 65) and larger.

B. Trapeze piping supports:

1. Field-fabricated from ASTM A 36 steel shapes.
2. Weld steel according to AWS D-1.1.
3. Size threaded rods in accordance with MSS SP-58.
4. Design trapeze support assembly based on supported load plus a 50 percent safety factor.

C. For hangers requiring vibration control, see Section 230548.

D. Hanger rod sizes:

PIPE SIZE NPS (DN)	ROD SIZE Inches (mm)
Up to 2 (Up to 50)	0.375 (10)
2.5 to 3.5 (65 to 90)	0.5 (15)
4 and 5 (100 to 125)	0.625 (16)
6 and 8 (150 to 200)	0.75 (20)

E. Horizontal piping generally shall be supported from above.

1. Attaching to walls: Use two 0.375-inch (9.5-mm) screw-type fasteners for attaching brackets and three 0.5-inch (13-mm) bolt-type fasteners for attaching structural supports.
2. Attaching to bar joists:
 - a. Pipes NPS 2.5 (DN 65) and smaller running parallel with joist: Hanger rods welded to top chord of joist at panel points.
 - b. Pipes NPS 2.5 (DN 65) and smaller running perpendicular to joist: Support from every other joist by method of hanging as described above.
 - c. Pipes NPS 3 (DN 80) and larger running parallel with joist: Support from a length of structural channel or angle welded to the top cords of at least two joists at panel points.
 - d. Pipes NPS 3 (DN 80) and larger running perpendicular to joist: Support from every joist by hanger rods welded to top chord of joist at panel points.
 - e. Where large numbers of pipes are grouped together, their individual hangers shall be staggered so as to distribute the load among the available joists.
3. Attaching to steel decks: Attach hanger rods to the hanger tabs on underside of deck, or pass them through the steel deck and secure on top side with nut, locknut and plate washer.
 - a. Plate washers: 4 by 8 inches by 0.125 inch thick (100 mm by 200 mm by 6 mm) for 0.375-inch and 0.5-inch (10 mm and 15 mm) rods; 6 by 12 inches by 0.187 inch (150 by 305 by 5 mm) thick for 0.625-inch (16-mm) and larger rods.
 - b. Top of hanger assembly shall be concealed in the concrete fill which will be placed over the deck.

F. Hangers and supports shall be spaced as follows:

1. Copper pipe:

- a. NPS 1.25 (DN 32) and smaller: At least every 6 feet (1.8 m).
 - b. NPS 1.5 and 2 (DN 40 and 50): At least every 8 feet (2.4 m).
 - c. NPS 2.5 (DN 65) and larger: At least every 10 feet (3 m).
2. Steel pipe:
 - a. NPS 1 (DN 25) and smaller: At least every 6 feet (1.8 m).
 - b. NPS 1.25 and 1.5 (DN 32 and 40): At least every 9 feet (2.7 m).
 - c. NPS 2 to 6 (DN 50 to 150): At least every 10 feet (3 m).
 - d. NPS 8 to 12 (DN 200 to 300): At least every 14 feet (4.3 m).
 - e. NPS 14 (DN 350) and over: At least every 20 feet (6.1 m).
 3. Plastic pipe with solvent cement or thermal-bonded joint:
 - a. NPS 2 (DN 50) and smaller: At least every 3 feet (0.9 m) when line carries liquid; for vent, 6 feet (1.8 m).
 - b. NPS 2.5 (DN 65) and larger: At least every 4 feet (1.2 m) when line carries liquid; for vent, 8 feet (2.4 m).
 - c. Provide protection shield between hanger and plastic pipe at each support point.
 4. Trapeze hangers:
 - a. Spacing shall not exceed the requirements for the smallest pipe in the rack.
 - b. For wood roof trusses, at least every 6 feet (1.8 m).
- G. Provide additional hangers or supports for concentrated loads such as flanges, valves, expansion compensators, fittings, and other specialties.
- H. Provide hangers as required for insulated piping systems. Coordinate selection of hangers and supports with requirements and selected options for insulation continuous through hanger or butted to each side. Provide pipe covering protection shield and structural insulation insert where insulation is continuous through hangers or supports.
- I. Provide pipe risers through floor slabs with riser clamps.
- J. Support PVC vertical risers at each floor and midway between floors.
- K. Support banks of pipes along the wall on a structural support system.
- 3.21 INSTALLING EQUIPMENT FOUNDATIONS AND SUPPORTS
- A. Provide four-inch (100-mm) -high concrete foundations (housekeeping pads) or as indicated on drawings, reinforced with welded-wire fabric, for floor-mounted equipment and where indicated. Anchor concrete foundations by dowels inserted into the floor slab.
 - B. Unless otherwise specified, provide concrete foundations, bolts, sleeves, and appurtenances as work of the section where the supported equipment is specified and in accordance with the requirements of Division 03.
 - C. Equipment shall be properly aligned and leveled, and grouted where necessary. Support piping independently of equipment and so as not to cause a strain or thrust.
 - D. Coordinate exact size, configuration and location of equipment, foundations, and supports using

approved shop drawings of equipment.

3.22 INSTALLING PIPE GUIDES

- A. Install guides where indicated on the drawings and where required to properly guide piping at expansion loops and joints.
- B. Install guides at distances recommended by the manufacturer, in accordance with MSS SP-58, and where indicated on the drawings.
- C. Guides do not support piping and do not serve as hangers or supports in determining spacing of hangers and supports.

3.23 INSTALLING ANCHORS

- A. Provide anchors where indicated or required by good piping practice to control pipe movement.
- B. Furnish and install heavy structural angle irons, channels, and wide flange beams as required for suitable anchor supports and bracing for the piping. Arrange anchor supports to suit field conditions, to be adequate for the required duty, and to transmit the thrust loads to the building structural system or floor slabs.
 - 1. Black steel pipes shall be welded to the supports for anchoring.
 - 2. Galvanized and copper pipes shall be attached to the supports by pipe clamps. Clamps for copper pipes shall be copper-plated or pipe shall be wrapped with lead sleeves.

END OF SECTION 230529

SECTION 230533 - HEAT TRACING FOR HVAC PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Electric heat tracing cable for protecting piping from freezing.

1.20 REFERENCES

- A. NFPA 70 (NEC) Article 427, Fixed Electric Heating Equipment for Pipelines and Vessels.
- B. IEEE Standard 515.1, Recommended Practice for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Commercial Applications.

1.30 SUBMITTALS

- A. Product data: Heat tracing cable and accessories.

1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 23 0500, Common Work Results for HVAC.
- B. Meet the requirements of the National Electrical Code (NEC) (NFPA 70), Section 427 and IEEE Standard 515.1.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. The following listed manufacturers provide units of acceptable quality.
 - 1. Chromalox
 - 2. Deltatherm
 - 3. Easy Heat, Inc.
 - 4. Pentair Thermal Management
 - 5. Thermon

2.20 HEATING CABLES

- A. Heating cable: Flexible, self-regulating electric resistance freeze protection cable consisting of parallel 16 AWG stranded buss wires embedded in a semi-conductive polymer core that varies heat output in response to temperature along its length. Cable shall be designed to be cut to length at the job site and for wrapping around valves or complex fittings. Self-regulation shall prevent overheating and burnouts even where the cable overlaps itself.
 - 1. Electrical insulating jacket: flame-retardant thermoplastic rubber over the polymer core and buss wire assembly.
 - 2. Cable Cover: Tinned-copper braid and water and chemical-resistant thermoplastic rubber outer jacket with ultraviolet inhibitor.
 - 3. End seals: Provide end seals for ends of circuits. Wires at the ends of circuits shall not be tied together.

B. Heat Output Density:

1. NPS 3 (DN 75) pipe and smaller (with 2-inch (50-mm) insulation): 3 watts per foot of pipe.
2. NPS 4 (DN 100) through NPS 6 (DN 150) pipe (with 2-inch (50-mm) insulation): 5 watts per foot of pipe.
3. NPS 8 (DN 200) pipe and larger (with 2-inch (50-mm) insulation): 8 watts per foot of pipe.

C. Accessories:

1. Power supply connection fittings and stainless steel mounting brackets. Provide stainless steel worm gear clamp to fasten bracket to pipe.
2. 0.5-inch (13-mm)-wide fiberglass reinforced pressure-sensitive cloth tape to fasten cable to pipe at 12-inch (305-mm) intervals.
3. Pipe surface temperature control thermostat: Cast aluminum, NEMA 4 (watertight) enclosure, 0.5-inch (13-mm) NPT conduit hub, SPST switch rated for 20 amps at system voltage, with capillary and copper bulb sensor. Set thermostat to maintain pipe surface temperature.
4. Signs: Manufacturer's standard meeting NEC requirements, stamped "ELECTRIC TRACED" located on the insulation jacket at 10-foot (3-m) intervals along the pipe on alternating sides.

PART 3 - EXECUTION

3.10 EXAMINATION

- A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.20 INSTALLATION

- A. Provide heat cable on piping in the following locations:
 1. Exterior piping aboveground and underground to below the frost line:
 - a. Chilled water
 - b. Chilled/heating water
 - c. Other locations indicated on the drawings
- B. Provide sufficient cable, as recommended by the manufacturer, to keep the pipe surface at 36 degrees F (4 degrees C) minimum during winter outdoor design temperature.
- C. Install electric heating cable across expansion joints according to manufacturer's written instructions; use slack cable to allow movement without damage to cable.
- D. Install electric heating cables after piping has been tested and before insulation is installed.
- E. Install electric heating cables directly to pipes and install thermostats in accordance with the manufacturer's recommendations and IEEE 515.1.
- F. Install insulation over piping with electric cables according to Section 230719 "HVAC Piping Insulation."

- G. Install warning tape on piping insulation where piping is equipped with electric heating cables.
- H. Set field-adjustable switches and circuit-breaker trip ranges.

3.60 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. 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.
 - 4. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.
 - 5. Cables will be considered defective if they do not pass tests and inspections.
 - 6. Prepare test and inspection reports.

3.70 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 - VIBRATION CONTROL SUPPORTS FOR HVAC

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Vibration control supports for HVAC equipment.

1.14 RELATED SECTIONS

- A. Hangers and supports: Section 230529.
- B. Flexible pipe connections: Section 230508.
- C. Flexible duct connections: Section 233300.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: For each type of vibration control support included in the work.
 - 1. For Specification D hanger, include scaled drawing showing degrees of hanger rod swing.
- C. Shop drawings: Custom-fabricated supports.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified Mason Industries product, or comparable product by one of the following:
 - 1. Amber/Booth Company, Inc.
 - 2. Kinetics Noise Control
 - 3. Mason Industries
 - 4. Vibro-Acoustics
 - 5. Vibration Eliminator Company, Inc.
 - 6. Vibration Mountings and Controls, Inc.

2.20 VIBRATION CONTROL SUPPORTS

- A. Provide engineered supports for equipment and locations shown on drawings and specified in Part 3 below. The units shall prevent the transmission of vibration and mechanically transmitted sound to the building structure.
 - 1. Select units in accordance with the weight distribution of the equipment, so as to produce reasonably uniform deflection. Deflections shall be as specified.
 - 2. Units installed on exterior shall be galvanized.
- B. Specification A: Equal to Mason Industries ND, double-deflection neoprene type. All metal surfaces shall be covered with neoprene and have friction pads both top and bottom. Provide bolt holes for mounting. Provide steel rails where necessary to compensate for equipment overhang.

- C. Specification B: Equal to Mason Industries SLFH, free-standing spring isolators, laterally stable without housing, and with 0.5-inch-(13-mm) thick neoprene pads between baseplate and support.
 - 1. Mountings shall have leveling bolts rigidly bolted to equipment.
 - 2. Springs: Spring diameters shall not be less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal of 50 percent of the rated deflection.
- D. Specification C: Equal to Mason Industries SLRW, galvanized spring type with neoprene pad top and bottom and with a housing that includes vertical resilient limit stops to prevent spring from extending when weight is removed. The housing shall serve as blocking during erection and the shims shall be removed after spring adjustment.
 - 1. Obtain data from the manufacturer of the supported equipment, and select springs individually to provide equal deflection with uneven point loading of the equipment.
- E. Specification D: Equal to Mason Industries Type 30N hangers, combination spring and minimum 0.3-inch (8-mm) deflection neoprene in series.
 - 1. Neoprene element: Molded with a rod isolation bushing that passes through the hanger box.
 - 2. Spring diameters and hanger box lower hole sizes: Large enough to permit the hanger rod to swing through a 30-degree arc before contacting the edges of the hole.
 - 3. Springs shall have a minimum additional travel to solid equal to 50 percent of rated deflection.
- F. Specification E: Equal to Mason Industries Type PC30N, same as Specification D, except with adjustment to transfer load to spring while holding supported object at fixed elevation. Include spring deflection indicator.
- G. Specification X: Equal to Mason Industries WB, horizontal thrust restraint, consisting of a spring element in series with a neoprene pad as described in Specification B with the same deflection specified for the mountings or hangers.
 - 1. Spring element: Contained within a steel frame and designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of 0.25 inch (6 mm) movement at start and stop.
 - 2. Furnish the assembly with one rod and angle brackets for attachment to both the equipment and ductwork or the equipment and the structure.
 - 3. Horizontal restraints: Attached at the centerline of thrust and symmetrically on either side of the unit.
- H. Specification W. Fifty-durometer neoprene waffle pads made from identical rubber grids molded back to back. The interconnections form suction pockets for gripping smooth steel as well as rough surfaces. The square waffle pattern is laid out on 0.5-inch (13-mm) centers to facilitate cutting pads to size in the field without the need for measuring.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Adjust vibration control supports as recommended by manufacturer to eliminate transmission of vibration to building structure or other systems.
- B. Replace springs that become permanently deformed with new springs.

- C. Provide 0.25-inch (6-mm) structural plate sized as required between isolator and equipment.

3.21 FAN VIBRATION CONTROL

- A. On floors above grade and on roofs: Provide Specification C mounting and with static deflection as scheduled below:

<u>Fan RPM</u>	<u>Minimum Static Deflection</u>
500 and over	1.75 (45 mm)
375 to 499	2.50 (65 mm)
300 to 374	2.75 (70 mm)
225 to 299	3.75 (95 mm)
175 to 224	4.75 (120 mm)

- B. Suspended from structure: Provide Specification D hanger, selected for weight, with minimum 1.0 inch static deflection.

3.22 AIR-HANDLING UNIT, ENERGY RECOVERY UNIT, AND DEDICATED OUTDOOR AIR SYSTEM VIBRATION CONTROL

- A. Isolators for air handling units may be provided as part of the unit (internal isolation) as specified in the section, Air Handling Units with Coils, but shall meet the requirements of this section.

- B. On floors above grade and on roofs: Provide number of Specification B mountings, having at least 1.75 inch (45 mm) static deflection, required to properly support unit and its accessories as recommended by the air-handling unit manufacturer.

- 1. Unit with fan section isolated from coil and filter section:

- a. Provide the Specification B mounting under fan and motor only, bolted to equipment support (housekeeping pad).
- b. Provide Specification X mounts on each side between fan and coil section to control fan section thrust upon fan start-up.

3.25 COMPRESSOR VIBRATION CONTROL

- A. Roof-mounted ductless split-system and variable refrigerant flow units: Specification W neoprene pads. Mount and set on equipment support curbs. Coordinate size and location of curbs with equipment manufacturer.

3.26 PUMP VIBRATION CONTROL

- A. Pumps mounted on floor slab on earth: No isolation required.

3.27 CHILLER VIBRATION CONTROL

- A. Chillers mounted on slab on earth: Specification A with 0.35 inch static deflection.

3.28 VERTICAL FAN-COIL UNIT VIBRATION CONTROL

- A. Where mounted on floors or metal stands, install on Specification W mountings.

3.29 VIBRATION CONTROLS ON PIPING

- A. Floor-mounted piping to pump: Specification A or B vibration isolator consistent with mounting of nearest isolated equipment.
- B. Piping: Provide Specification E vibration control supports in first three hangers at both the suction and discharge of pumps, chillers, compressors, and condensing units, and for the first three hangers on pipes connected to air handling units. The static deflection shall be the same as specified for the mountings under the connected equipment.
 - 1. If piping is connected to equipment mounted on slab on grade and hangs from structure under occupied spaces, the first three hangers shall have at least 0.75 inch (19 mm) deflection for pipe sizes up to and including NPS 3 (DN 80), 1.5 inch (38 mm) deflection for pipe sizes up to and including NPS 6 (DN 150) and 2.5 inch (64 mm) deflection thereafter.
 - 2. Other hangers and mounts shall have a minimum spring deflection of 0.75 inch (19 mm).
 - 3. Locate vibration control supports in hanger rods as close to the overhead supports as practical. On supports with double rods, use two vibration control supports.

END OF SECTION 230548

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. The Contractor shall engage and the Architect shall approve an independent balancing and testing subcontractor.
- B. This section includes testing, adjusting, and balancing HVAC systems to produce design objectives, including the following:
 - 1. Balancing airflow and water flow within distribution systems, including submains, branches, and terminals, to indicated quantities according to specified tolerances.
 - 2. Adjusting total HVAC systems to provide indicated quantities.
 - 3. Measuring electrical performance of HVAC equipment.
 - 4. Setting quantitative performance of HVAC equipment.
 - 5. Verifying that automatic control devices are functioning properly.
 - 6. Reporting results of the activities and procedures specified in this section.

1.14 RELATED SECTIONS

- A. Testing and adjusting requirements unique to particular systems and equipment are included in the sections that specify those systems and equipment.
- B. Field quality-control testing to verify that workmanship quality for system and equipment installation is specified in system and equipment sections.

1.27 PERFORMANCE REQUIREMENTS

- A. Select and obtain approval of the testing and balancing subcontractor at the earliest possible time and before beginning ductwork installation.
- B. The testing and balancing subcontractor shall visit the job site periodically, beginning with the initial stages of construction of the mechanical systems, and shall ensure that the necessary devices are properly installed so that specified testing and balancing can be performed.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Submit qualifications of testing and balancing subcontractor, as required in article "Quality Assurance" below.
- C. Submit certified balance report. In addition to general requirements for submittals, submit three copies of final reports and certificates, bound into a booklet.

1.40 QUALITY ASSURANCE

- A. Testing and balancing subcontractor qualifications:
 - 1. Current certified member of the Associated Air Balance Council, or certified by National Environmental Balancing Bureau for air and hydronic systems testing and balancing.
 - 2. Has successfully completed at least five projects of similar size and scope.

3. Not affiliated with any other subcontractor participating in this project. Work performed by the subcontractor shall be limited to testing, adjusting, and balancing HVAC systems.

B. Testing and balancing work shall comply with one of the following standards:

1. National Standards for Testing and Balancing Heating, Ventilating and Air Conditioning Systems, published by the Associated Air Balance Council.
2. Procedural Standards for Testing Adjusting Balancing of Environmental Systems, published by the National Environmental Balancing Bureau.

PART 2 - PRODUCTS

2.30 EQUIPMENT

A. Instruments: Approved and properly calibrated.

1. Measure pump and coil pressure differentials with mercury manometers.
2. Measure air temperature with mercury thermometers.
3. Pyrometer surface temperature measurements may be used for piping system water temperatures where thermometer wells are not provided in the piping.

PART 3 - EXECUTION

3.02 VERIFICATION OF CONDITIONS

- A. Before beginning balancing, ascertain that systems are ready. Verify that filters for regular service are in place, as required in Section 234100, Particulate Air Filtration.

3.05 PREPARATION

- A. Witness air duct leakage tests required in Section 233113, Metal Ducts, and advise and approve the methods and instruments used.
- B. Using bench-calibrated instruments, field-calibrate pressure gages and dial-type duct thermometers.

3.21 BALANCING OF SYSTEMS, GENERAL

- A. Tabulate settings of temperature control devices and ascertain that thermostats, controllers, and valves are set at specified or approved positions. Verify and certify that the sequence of operation for each system is as shown on drawings, specified, or approved.
- B. Provide all labor and devices necessary for the testing and balancing work.

3.22 AIR SYSTEMS BALANCING

- A. Balance all air distribution, supply, return, exhaust, and outdoor air systems and equipment.
- B. Test and adjust fans to deliver design airflow at lowest possible speed. Adjust air-handling equipment to deliver the required air volumes. Note that air quantities scheduled on drawings do not include allowances for duct leakage. Preliminary adjustments of fan speed should be slightly in excess of scheduled airflow delivery. Make adjustments by adjusting adjustable sheaves, changing sheaves and associated belts, changing wiring connections of motors, or adjusting speed controller.

- C. Test and adjust system to design airflow requirements to the greatest extent possible. Manual volume dampers in ducts shall be adjusted to obtain required airflow rates at grilles, registers, and diffusers. Dampers integral to airflow devices should be fully open or minimally closed for airflow fine adjustments.
- D. Make pitot tube traverse of main supply, return, and outdoor air ducts to obtain total airflow for fan or air-handling unit.
- E. Adjust rooms or zones to design airflow (supply, return, and exhaust).
- F. Adjust general HVAC systems to design airflow within the following tolerances:
 - 1. Total system supply, return, and exhaust: (design to plus 10 percent).
 - 2. Outdoor air: (minus 5 percent to plus 5 percent).
 - 3. Total supply, return, and exhaust for a room or space: (minus 5 percent to plus 5 percent).
 - 4. Grilles, registers, and diffusers:
 - a. One per room or space: (minus 5 percent to plus 5 percent).
 - b. Two or more per room or space: (minus 10 percent to plus 10 percent).
- G. Grilles, registers, and diffusers:
 - 1. Identify each grille, register, and diffuser as to location and area. List manufacturer, type, and size.
 - 2. Identify type of testing equipment used.
 - 3. Test and adjust each grille, register, and diffuser to design airflow. List (design-actual) cfm (cubic meters per minute) and (design-actual) velocity in fpm (meters per second) when applicable.
 - 4. Adjust diffusers, grilles, and registers to minimize drafts. Adjust blades in supply diffuser straightening grids to assure uniform air distribution across diffuser.
 - 5. Adjust linear slot diffusers to provide throw direction as indicated on the drawings. Unless otherwise noted, discharge pattern shall be horizontal. Where two-way throw is indicated, divide the number of slots equally for each direction.
- H. Test and record the following data, as applicable, for air-handling equipment:
 - 1. Manufacturer and model number.
 - 2. Total airflow (design-actual).
 - 3. Return air airflow (design-actual).
 - 4. Outdoor air airflow (design-actual).
 - 5. Total and external static pressure (design-actual). Include static pressure at suction, discharge, and between unit coil and filter components.
 - 6. Entering air temperatures (db heating, db and wb cooling).
 - 7. Leaving air temperatures (db heating, db and wb cooling).
 - 8. Motor horsepower (rated-actual).
 - 9. Voltage and phase (rated-actual).
 - 10. Fan speed, rpm (rated-actual).
 - 11. Amperage (rated-actual).
- I. In cooperation with the control manufacturer's representative, set adjustments of automatically operated dampers to operate as specified.

3.24 HYDRONIC SYSTEMS BALANCING

- A. Balance all hydronic piping systems.
- B. Adjust flow rates for constant-speed pumps that are not controlled by variable frequency drives using the balancing valve in the pump discharge. Valves at constant-speed pumps controlled by variable frequency drives shall be fully open and the pump flow rates shall be adjusted using their variable frequency drives. Valves at variable flow pumps controlled by variable frequency drives shall be fully open with no adjustment made to the variable frequency drive.
- C. Adjust and balance the following items listed under the various systems in accordance with the specified standards. Units with automatic flow control valves, measure and document the differential pressure across the valve to ensure it is within the specified operating range.
 - 1. Domestic hot water system:
 - a. Pump
 - b. Return piping for flow to every branch
 - 2. Chilled water system:
 - a. Pump
 - b. Chiller
 - c. Chilled water coil
 - 3. Heating system:
 - a. Pump
 - b. Convector
 - c. Unit heater
 - d. Finned pipe radiation
 - e. Boiler
 - f. Air-handling unit
 - g. Duct coil
 - h. Cabinet unit heater
- D. After the above items have been adjusted and balanced, submit a certified report listing the specification requirements and the operating conditions of these items as follows:
 - 1. Pump:
 - a. Flow - gpm
 - b. Suction pressure
 - c. Discharge pressure
 - d. Pressure differential
 - e. Total dynamic head
 - f. Motor - HP voltage, hertz, phase, design full load amps
 - g. Motor - operating line voltage and amperage, overload heater ratings.
 - 2. Chilled water coil:
 - a. Flow - gpm
 - b. Entering air - D.B.
 - c. Entering air - W.B.

- d. Leaving air - D.B.
 - e. Leaving air - W.B.
 - f. Entering water temperature
 - g. Leaving water temperature
 - h. Pressure drop across coil
 - i. Outdoor air temperature - D.B.
 - j. Outdoor air temperature - W.B.
3. DX coil:
- a. Suction pressure
 - b. Suction line temperature
 - c. Entering air - D.B.
 - d. Entering air - W.B.
 - e. Leaving air - D.B.
 - f. Leaving air - W.B.
 - g. Outdoor air temperature - D.B.
 - h. Outdoor air temperature - W.B.
4. Heating water coil (such as coils in air-handling units, unit heaters, convectors, and reheat coils):
- a. Flow - gpm
 - b. Entering water temperature
 - c. Leaving water temperature
 - d. Entering air - D.B.
 - e. Leaving air - D.B.
5. Chiller and Boilers:
- a. Flow - gpm
 - b. Entering water temperature
 - c. Leaving water temperature
 - d. Pressure drop across chiller
 - e. Motor - HP voltage, hertz, phase, design full load amps.
 - f. Motor - operating amps & volts - install overload heater rating
6. Piping system:
- a. Flow - gpm reading of flow meter in various systems: See drawings for locations.

3.26 MARKING OF SETTINGS

- A. Following final balance procedures, permanently mark the settings of valves, splitters, dampers, and other adjustment devices so that adjustment can be restored if disturbed at any time. Set memory stops on balancing valves. Return and make required adjustments after submittal and approval of the Certified Balance Report.

END OF SECTION 230593

SECTION 230700 - HVAC INSULATION

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Definitions and general requirements applicable to the insulation systems specified in "Related Sections."

1.14 RELATED SECTIONS

- A. Pipe insulation: Section 230719.
- B. Duct insulation: Section 230713.
- C. Equipment insulation: Section 230716.

1.20 DEFINITIONS

- A. Ceiling space: The space between the ceiling and the floor of an air-conditioned space above.
- B. Roof space: The space between the ceiling and the roof, where building insulation is located at the roof level, or the space between the ceiling and the floor of a non-air conditioned space above.
- C. Attic space: The space between the ceiling and the roof, where building insulation is located at the ceiling level.
- D. Air-conditioned areas or spaces: Areas or spaces where the occupied room temperature is maintained between 65 and 80 degrees F (18.3 and 26.7 degrees C).
- E. Concealed insulation shall include work:
 - 1. Above ceilings.
 - 2. Where furred in and in pipe chases.
- F. Exposed insulation shall include work:
 - 1. Below ceilings in all rooms and areas.
 - 2. In mechanical equipment rooms or mechanical closets.
 - 3. In all rooms without ceilings.
 - 4. In storage rooms.

1.40 QUALITY ASSURANCE

- A. Perform work in strict accordance with the building, fire and safety codes of the state, county or city in which the work is performed.
- B. Insulation, including fittings and butt strips, jackets, facings, and accessories such as adhesives, mastics, cements, tapes and cloth, shall have a fire and smoke hazard rating and label as tested by ASTM E84, NFPA 255, and UL 723, not exceeding Flame Spread 25, Fuel Contributed 50, Smoke Developed 50.
- C. All insulation and accessories shall be free of asbestos.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Deliver insulation and accessory products in manufacturers' wrapping or cartons, identified on the exterior and bearing labels showing conformance to flame and smoke rating requirements.

PART 2 - PRODUCTS

2.10 MATERIALS

- A. Refer to sections listed in "Related Sections."

PART 3 - EXECUTION

Not Used.

END OF SECTION 230700

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Insulation applied to ducts.

1.14 RELATED SECTIONS

- A. Sections specifying requirements for LEED rating are specified in Division 01.
- B. Painting: Division 09.
- C. Definitions of concealed, exposed, and other terms: Section 230700.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. LEED submittal:
 - 1. Product data for credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.
- C. Material list: Each type of insulation and accessory, with manufacturer's name and material name and number. Identify locations for use, thickness of material, type of jacket, vapor barrier, and method of application.
- D. Product data: Sufficient to show that the product meets the specified requirements for materials, composition, and performance.

1.40 QUALITY ASSURANCE

- A. Meet requirements specified in Section 230700.
- B. Comply with requirements for LEED certification specified in Division 01.
- C. Installer qualifications: Firm with at least 5 years successful installation experience with mechanical insulation. Work shall be performed by mechanics skilled in this trade.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Meet requirements specified in Section 230700.
- B. Store rigid insulation products so as to protect them from breakage.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. The listed manufacturers and particular products are intended to set a standard for materials, composition, and performance. Products of other manufacturers may be proposed as permitted by the provisions of Division 01 and the article "Product Options" in Section 230101.
- B. Insulation and accessories:
 - 1. Armstrong World Industries.
 - 2. CertainTeed Corporation.
 - 3. Childers.
 - 4. Foster.
 - 5. Johns Manville.
 - 6. Knauf Fiber Glass GmbH.
 - 7. Owens-Corning.

2.10 MATERIALS

- A. Flexible fiberglass insulation: ASTM C 553, Type I, K-factor of 0.27 at 75 degrees F (0.037 at 24 degrees C) mean temperature, of thicknesses specified in Part 3 below, nominal density at least 1 lb per cubic foot (16 kg per cubic meter), with vapor-barrier jacket of reinforced kraft and aluminum foil.
- B. Rigid fiberglass insulation: ASTM C 612, Types IA-IB, nominal density at least 6 lbs per cubic foot, with K-factor of 0.22 at 75 degrees F (0.032 at 24 degrees C) mean temperature, of thicknesses specified in Part 3 below, with factory-applied jacket composed of a reinforced white kraft and aluminum-foil laminate with the white kraft facing out, equal to CertainTeed CertaPro Commercial Board CB 600.
- C. Canvas: Eight ounces/sq. yd. (270 g/sq. m.), fire-retardant treated. Provide washable, abrasion-resistant finish coating equal to Foster "Sealfas" 30-36.
- D. Adhesives for duct insulation inside buildings: Recommended by insulation manufacturer for the application, equal to Foster Products 85-60.
- E. Vapor barrier coating: Equal to Foster 30-65.
- F. Adhesive fasteners: Equal to Duro Dyne perforated base adhesive hanger (PBH). Minimum 12-gauge zinc-plated steel pin with 2 inch by 2 inch, 28 gauge galvanized base and retaining washer. Pin length as required. Comply with ASTM-A591 and SMACNA HVAC Duct Construction for Mechanical Fasteners.
- G. Glass cloth and tape: MIL-C-20079. Tape: Type II, Class 3, 4.5 ounces/sq. yd. (150 g/sq. m.) Cloth: Type I, Class 1, untreated.
- H. Self-adhesive tape: Manufacturer's standard tape of material matching insulation jacket, with peelable backing and pressure-sensitive adhesive.
- I. Mastic for ductwork exposed to weather: Equal to Foster 30-90 mastic/coating.
- J. Elastomeric sheet roofing:

1. Membrane: 0.045-inch-thick (1-mm-thick) reinforced EPDM.
2. Seaming materials: Recommended by membrane manufacturer.
3. Flexible counterflashing: Uncured EPDM, by manufacturer of roofing membrane and recommended for use with it.
4. Color: White.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Apply insulation in a neat and workmanlike manner and in accordance with manufacturer's printed instructions. Butt joints tightly and apply a brush coat of adhesive to laps and joint strips. Seal laps, pulling jacketing tight and smooth. Tape joints with self-adhesive tape matching the service jacket.
- B. Tape and seal terminations of insulation to prevent "dusting".

3.21 INSULATION INSIDE BUILDINGS

- A. Concealed ducts: Flexible fiberglass insulation. On ducts more than 30 inches (762 mm) wide, secure insulation on the underside with mechanical fasteners as required to prevent sagging. Butt insulation with facing overlapping at least 2 inches (50 mm) and sealed with vapor-barrier adhesive. Adhesive must cover full 2-inch (50-mm) overlap to form an airtight seal. Seal breaks and punctures with vapor-barrier tape and vapor barrier coating.
- B. Exposed ducts: Rigid fiberglass insulation, fastened with mechanical fasteners. Fasteners shall be spaced 12 to 18 inches (305 to 457 mm) on center with a minimum of two rows per side of duct. Secure insulation in place with washers firmly embedded in insulation.
 1. Install corner beads on external corners.
 2. Seal joints. Apply canvas jacket. Cover with two coats of lagging adhesive, ready for painting. Fastener caps shall match the jacket.
- C. For curved surfaces, such as exposed elbows, score or cut insulating board in narrow strips as necessary for snug and neat fit.
- D. Ductwork which need not be insulated:
 1. Cooling systems:
 - a. Lined, preinsulated round or insulated flexible supply ducts where installed in:
 - (1) Ceiling spaces of air-conditioned spaces.
 - b. Supply ducts where exposed in areas they serve.
 - c. Lined, preinsulated round or insulated flexible return ducts, except in attic spaces.
 - d. Return ducts in ceiling spaces of air-conditioned areas. Note that insulation is required for return ducts in roof spaces.
 - e. Return ducts exposed in areas they serve.
 - f. Return duct in return-air ceiling plenums.
 2. Heating systems:

- a. Lined, preinsulated round or insulated flexible supply ducts, except in attic spaces.
- b. Supply ducts exposed in areas they serve.
- c. Return ducts, except in attic spaces.
- d. Transfer ducts, except in attic spaces.

3.22 INSULATION THICKNESS

- A. Outdoor air ducts: 1.5 inches (40 mm). Where necessary to conceal the standing seams and reinforcing angles on exposed ducts, 2 inches (50 mm).
- B. Exhaust air ducts to roof ventilators or to exterior openings: 1.5 inches (40 mm), starting at connection to roof curb or opening and running back to ATC dampers but not less than 10 feet (3 m).
- C. Exhaust ducts from air-conditioned areas, in roof or attic space: 1.5 inches (40 mm).
- D. Ductwork which transmits combination cooled and heated air or untempered ventilating air shall be insulated as specified below for cooling systems.
- E. Conditioned or supply air ducts from dedicated outdoor air systems shall be insulated as specified for supply air ducts.
- F. Return or exhaust air ducts from dedicated outdoor air systems shall be insulated as specified for return air ducts.
- G. Cooling systems:
 1. Supply air ducts: 1.5 inches (38 mm). Where necessary to conceal the standing seams and reinforcing angles on exposed ducts, 2 inches (50 mm).
 - a. Exception: Lined or unlined supply ducts in attic spaces: 2 inches (50 mm).
 2. Return air ducts: 1.5 inches (40 mm). Where necessary to conceal standing seams and reinforcing angles on exposed ducts, 2 inches (50 mm).
 - a. Exceptions:
 - (1) Return ducts in attic spaces: 2 inches (50 mm).
 - (2) Lined, preinsulated round or insulated flexible return ducts in attic spaces: Externally insulated with 1.5-inch (40-mm)-thick insulation.
 3. Transfer ducts shall be insulated as specified for return ducts.
- H. Heating systems:
 1. Supply air ducts: 1.5 inches (40 mm). Where necessary to conceal the standing seams and reinforcing angles on exposed ducts, 2 inches (50 mm).
 - a. Exception: Supply ducts in attic spaces: 2 inches (50 mm).
 2. Return ducts in attic spaces: 2 inches (50 mm).
 3. Transfer ducts shall be insulated as specified for return ducts.

- I. Casings and headers of reheat coils shall be insulated with the same thickness as adjacent ductwork.

END OF SECTION 230713

SECTION 230716 - HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Equipment insulation as scheduled at end of section.

1.14 RELATED SECTIONS

- A. Sections specifying requirements for LEED rating are specified in Division 01.
- B. Definitions and general insulation requirements: Section 230700.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. LEED submittal:
 - 1. Product data for credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.
- C. Material list: Each type of insulation and accessory, with manufacturer's name and material name and number. Identify locations for use, thickness of material, type of jacket, vapor barrier, and method of application.
- D. Samples required only upon request.
- E. Manufacturer's installation instructions and system recommendations.

1.40 QUALITY ASSURANCE

- A. Meet requirements specified in Section 230700.
- B. Comply with requirements for LEED certification specified in Division 01.
- C. Installer qualifications: Firm with at least 5 years successful installation experience with mechanical insulation. Work shall be performed by mechanics skilled in this trade.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Meet requirements specified in Section 230700.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. The listed manufacturers and particular products are intended to set a standard for materials, composition, and performance. Products of other manufacturers may be proposed as permitted by the provisions of Division 01 and the article "Product Options" in Section 230101.
- B. Insulation and accessories:

1. Armacell.
2. CertainTeed Corporation.
3. Childers.
4. Foster.
5. Johns Manville
6. Knauf Fiber Glass GmbH.
7. Owens-Corning.

2.10 EQUIPMENT INSULATION

- A. Insulation types refer to the Equipment Insulation Schedule at the end of the section. Thicknesses are scheduled.
- B. Type B, insulation for cooled surfaces: Flexible elastomeric insulation, ASTM C 534, Type II, with vapor barrier facing.
- C. Insulating and finishing cement: Mineral fiber cement with a hydraulic-setting binder, conforming to ASTM C 449.
- D. Insulation compounds: Provide adhesives, cements, sealers, mastics, and protective finishes recommended by manufacturers of insulation for each particular application.
- E. Insulation accessories: Provide staples, bands, wire, wire mesh, tape, corner angles, anchors, and stud pins recommended by manufacturer of insulation for each particular application.
- F. Jacket material: Pre-sized glass cloth, not less than 7.8 ounces per sq. yd. (271 g per sq. m).

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Insulate equipment as specified, except equipment with factory-applied insulation. Follow manufacturer's instructions.
- B. Provide removable insulation sections to cover parts of equipment which must be opened or removed periodically for maintenance, such as vessel covers, fasteners, flanges, pump casings and strainers, frames, and accessories. On large vessels, provide additional external support.
 1. On hot equipment, insulate equipment surface, leaving flanges, bolts, and other accessories exposed.
 2. On cold equipment, or equipment used for both heating and cooling, insulate flanges and accessories, and make insulation separately removable.
- C. Maintain the integrity of vapor barriers.
- D. Do not insulate boiler manholes, handholes, cleanouts, ASME stamp, or manufacturer's nameplate. Bevel edges at interruptions.
- E. On breechings, install insulation on standoffs, with required air space.

3.21 INSTALLATION ON COLD SURFACES

- A. Type in accordance with Equipment Insulation Schedule.

- B. Cut, score, or miter insulation to fit contours of equipment. Secure with a full coating of adhesive. Provide weld pins or stick clips with washers spaced 18 inches apart. Stagger joints between layers.
- C. Fill voids with small pieces of insulation applied with adhesive on all sides to maintain complete vapor barrier. Seal joints, breaks, and punctures in facing.
- D. Insulation on chilled water and chilled/heating water pumps: For each pump, construct an insulated box assembly with removable cover, or access panels.
 - 1. Size: To surround pump housing, drive shaft, and piping, including suction diffuser, and allowing clearance for draining and adjustment of pump shaft seal.
 - 2. Construction: 18-gage galvanized steel; formed with edge returns so that insulation is not exposed; provided with openings for drive shaft and pipes; no part resting on pump.
 - 3. Access: Design box for disassembly or access. Provide fasteners such as clips or cam latches, so that access is possible without the use of tools.
 - 4. Insulation: Secured to inside of box with pins and adhesive.

3.22 INSTALLATION ON HOT SURFACES

- A. Type in accordance with Equipment Insulation Schedule.
- B. Cut, score, or miter insulation to fit contour of equipment and secure with 0.5 by 0.015 inch (13 by 0.4 mm) galvanized steel bands on 12-inch (305-mm) centers. Use weld pins or stick clips with washers for flat surfaces, spaced 18 inches (760 mm) apart. Stagger joints where possible and fill voids with insulating cement. Apply wire mesh over entire surface of equipment and corner beads to all outside corners and edges.

3.23 INSTALLING FINISHED SURFACE

- A. Apply a coat of insulating cement to smooth out surface. When cement is dry apply a coating of lagging adhesive. Embed a layer of glass cloth, overlapping all seams 2 inches (50 mm), and finish with a second coat of same adhesive.

3.90 EQUIPMENT INSULATION SCHEDULE

(See Schedule, next page)

EQUIPMENT	INSULATION TYPE	THICKNESS INCHES
Chilled water and chilled/heating water air separators	B	2 layers each 0.75
Chiller cold surfaces (not factory-insulated)	B	2 layers each 0.75
Chilled water and chilled/heating water pump box assemblies	B	2 layers each 0.75
Chilled water and chilled/heating water expansion tank	B	2 layers each 0.75

END OF SECTION 230716

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. HVAC piping insulation for the piping systems listed in the schedule at the end of this section.

1.14 RELATED SECTIONS

- A. Sections specifying requirements for LEED rating are specified in Division 01.
- B. Definitions and general insulation requirements: Section 230700.
- C. Painting: Division 09.
- D. Pipe hangers and protection shields: Section 230529.
- E. Electric heat cable (heat tracing): Section 230533.

1.20 REFERENCES

- A. ASTM C 450: Prefabrication and Field Fabrication of Thermal Insulating Fitting Covers for NPS Piping, Vessel Lagging, and Dished Head Segments.
- B. ASTM C 534: Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- C. ASTM C 547: Mineral Fiber Pipe Insulation.
- D. ASTM C 553: Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
- E. ASTM C 1094: Standard Guide for Flexible Removable Insulation Covers.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. LEED submittal:
 - 1. Product data for credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.
- C. Schedule of products: Each type of insulation and accessory, with manufacturer's name and material name and number. Identify locations for use, thickness of material, type of jacket, vapor barrier, and method of application.
- D. Product data: Sufficient to show that the product meets the specified requirements for materials, composition, and performance.
- E. Samples required only upon request.

1.34 QUALITY CONTROL SUBMITTALS

- A. Manufacturer's instructions: Recommended accessory materials and products; installation instructions.

1.40 QUALITY ASSURANCE

- A. Meet requirements specified in Section 230700.
- B. Comply with requirements for LEED certification specified in Division 01.
- C. Installers shall be mechanics skilled in this trade.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Meet requirements specified in Section 230700.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. The listed manufacturers and particular products are intended to set a standard for materials, composition, and performance. Products of other manufacturers may be proposed as permitted by the provisions of Division 01 and the article "Product Options" in Section 230101.
- B. Fiberglass insulation:
 - 1. Johns Manville.
 - 2. Knauf Fiber Glass GmbH.
 - 3. Owens-Corning.
- C. Flexible elastomeric insulation:
 - 1. Armacell LLC
 - 2. Rubatex
- D. Coatings, adhesives, and fabrics:
 - 1. Childers.
 - 2. Foster.
 - 3. Manville Building Materials Group.
 - 4. Rock Wool Manufacturing Company

2.10 FIBERGLASS PIPE INSULATION

- A. Fiberglass insulation: Glass fibers bonded with a thermosetting resin.
 - 1. Preformed pipe insulation, ASTM C 547 Type I, with all-service jacket.
 - 2. Flexible sheet insulation, ASTM C 553 Type IV, without facing.
- B. All-service jacket (ASJ) or "Evolution" Paper-free ASJ: Factory-applied, fire-retardant, vapor-barrier foil/scrim/kraft jacket. All-service jacket with self-sealing lap (ASJ-SSL) is acceptable as Contractor's option.

1. Tape: Matching jacket, pressure-sensitive.

C. Fittings and valves: Prefabricated and field fabricated, meeting ASTM C 450 requirements for dimensions used in forming insulation to cover valves, elbows, tees, and flanges.

2.12 FLEXIBLE ELASTOMERIC PIPE INSULATION

A. Flexible elastomeric tube and sheet: Equal to Armacell "AP Armaflex," or "Armaflex 2000", closed-cell, sponge- or expanded-rubber materials, ASTM C 534, Type I (tubular) and Type II (sheet).

B. Fitting and valve covers: Field fabricated, meeting ASTM C 450 requirements for dimensions used in forming insulation to cover valves, elbows, tees, and flanges.

2.16 ADHESIVES

A. Joints, fittings, and general application:

1. Fiberglass insulation: Foster "Quick-Tack" 85-60.
2. Flexible elastomeric insulation: Foster "Drion" 85-75.

B. Lagging adhesive: Polyvinyl acetate adhesive, equal to Foster "Lagfas" 81-42W.

2.17 MASTICS AND COATINGS:

A. Flexible elastomeric insulation: Armacell "WB Armaflex" latex enamel.

B. Insulating and finishing cement: Mineral fiber cement with a hydraulic-setting binder, conforming to ASTM C 449.

C. Vapor barrier coating:

1. On fiberglass insulation: Foster "Vapor-Fas" 30-65.
2. On flexible elastomeric insulation: Two coats of latex enamel coating.

D. Finish coating for fiberglass insulation or lagging: Washable, abrasion-resistant, coating equal to Foster "Seafas" 30-36.

2.18 LAGGING AND REINFORCING TEXTILES

A. Canvas: Eight ounces/sq. yd. (270 g/sq. m), fire-retardant treated.

B. Glass cloth and tape: MIL-C-20079. Tape: Type II, Class 3, 4.5 ounce/sq. yd. (150 g/sq. m). Cloth: Type I, Class 1, untreated.

2.19 FASTENERS

A. Aluminum bands: 0.75 inches (19 mm) wide and 0.020 inches (0.4 mm) thick.

B. Staples: Outward clinching type, Type 304 or 316 stainless steel.

C. Pins: Serrated shaft, Type 304 or 316 stainless steel.

2.20 PROTECTIVE PIPE JACKETS

- A. Aluminum: Smooth aluminum 0.016-inch-thick, lined with a bonded moisture barrier, equal to Childers "Aluminum Roll Jacketing."
 - 1. Aluminum straps: Same alloy as jacket.
 - 2. Elbows: Childers "Univers-Ell Jacs".
 - 3. Tees: Childers "Tee-Jacs."
 - 4. Fitting covers: Manufacturer's factory-fabricated aluminum covers suitable to size of fitting and thickness of insulation.
- B. Polyvinyl chloride (PVC): High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; 20 mils (0.5 mm) thick; roll stock ready for shop or field cutting and forming.
 - 1. Adhesive: As recommended by jacket material manufacturer.
 - 2. Color: White.
 - 3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. 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.
- C. Canvas: Finished with lagging coating, uniform, smooth, and ready for painting.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Install in accordance with the Minimum Thickness Schedule at the end of this section, as modified by specifications for each location and type.
- B. Fiberglass insulation: Apply insulation to a neat and smooth finish. Comply with manufacturers' recommendations and installation instructions. Butt joints tightly and apply a brush coat of vapor barrier coating to each lap and joint strip. Seal or fasten laps in jacketing as specified for location, pulling jacketing tight and smooth. Coat all fittings, valves, and flanges with vapor barrier coating and reinforcing mesh before applying fitting covers.
- C. Flexible elastomeric insulation: Apply by slipping seamless sections of tubing over the end of the piping, wherever possible. Use slit tubing only as necessary. Seal joints and slit seams with joint adhesive.
 - 1. Fittings and valves: Field fabricated from insulation same thickness as on the piping. Use manufacturer's miter tubes and boxes and templates.
- D. Tape and seal with vapor barrier coating to all terminations of insulation.
- E. Staple, tape, or seal plastic pipe fitting covers by methods recommended by manufacturer.
- F. Coordination with pipe hangers and supports:
 - 1. Insulation shall be continuous through hangers for all piping systems. Install pipe covering protection shields with thickness of structural insulation inserts equal, under load, to that of adjoining insulation. Shields and saddle supports are specified in Section 230529, Hangers and Supports for HVAC Piping and Equipment.

3.21 INSTALLING INSULATION AT PENETRATIONS

- A. Where the insulated piping systems pass through sleeves or openings in partitions and floors, the insulation shall be continuous through the sleeves and openings. See Firestopping specifications, for coordinating insulation and fire protection sealing.

3.22 INSTALLING CANVAS JACKET

- A. Locations:
 - 1. All pipe insulation in mechanical rooms, and mechanical closets and on exposed piping as defined in Section 230700, HVAC Insulation.
 - 2. Canvas jacket is not required where aluminum jacket is required.

3.23 INSTALLING ALUMINUM JACKET

- A. Locations: All insulated pipe exposed in finished areas within 8 feet (2440 mm) of the finished floor.
- B. Secure jacket with aluminum bands on 12-inch (305-mm) centers and at circumferential joints.
- C. Place longitudinal joints to face a wall and overhead joints to face the ceiling.

3.24 INSTALLING PVC JACKET

- A. Locations: As specified for weather protection.
- B. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of pipes. 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.
 - 2. Seams and joints shall completely prevent the entrance of water.

3.26 INSTALLING HEATING PIPING INSULATION

- A. Piping systems:
 - 1. Heating water
- B. Insulation: Fiberglass pipe insulation with jacket, in accordance with Minimum Thickness Schedule. Staple or seal ASJ laps at Contractor's option.
- C. Fittings, valves, and covers: Cover with prefabricated fitting covers.
- D. Casings and headers of heating water coils: Fiberglass same thickness as on adjacent piping. Finish with a layer of glass cloth embedded in two coats of lagging coating.
- E. Insulation on strainers: Removable without damage.

3.27 INSTALLING CHILLED AND CHILLED/HEATING WATER PIPING INSULATION

- A. Piping systems: Insulate supply and return with fiberglass insulation in accordance with Minimum Thickness Schedule. Seal ASJ lap to form vapor barrier.
- B. At all valves, flanges, and fittings, and at intervals of not more than 21 feet (6400 mm) on continuous runs of pipe, make a joint in insulation. Finish and seal ends with vapor barrier coating on both sides of joint.
- C. Fittings, valves, and flanges: Cover with prefabricated fitting covers. Coat all fittings, valves, and flanges with vapor barrier coating and reinforcing mesh before applying fitting covers.
- D. Casings and headers of cooling coils: Fiberglass of thickness equal to that of adjoining pipe insulation, finished with vapor-barrier jacket.
- E. Insulation on strainers: Removable without damage.

3.30 INSTALLING REFRIGERANT PIPING INSULATION

- A. Piping systems: All refrigerant suction, hot gas, and liquid piping; indoors and outdoors. Insulate refrigerant discharge lines where there is a possibility of contact by people other than service personnel.
- B. Insulation: Flexible elastomeric, thickness in accordance with Minimum Thickness Schedule.
- C. Fittings and valves:
 - 1. Coat with vapor barrier coating.
 - 2. Field-fabricated covers same thickness as on adjacent piping.

3.31 INSTALLING EXTERIOR PIPING INSULATION

- A. Locations: Piping systems exterior of building heated space.
 - 1. Chilled water and chilled/heating water
 - 2. Refrigerant hot gas
 - 3. Refrigerant liquid
 - 4. Refrigerant suction
 - a. Where required, install electric heat cable before applying insulation.
- B. Insulation: As specified for the same system interior, minimum thickness 2 inches (50 mm), or 0.5 inches (13 mm) thicker than scheduled for interior insulation on similar system, whichever is greater.
- C. Start insulation 30 inches (760 mm) below grade, 30 inches (760 mm) below roof or 30 inches (760 mm) inside exterior wall. Secure insulation with aluminum bands on 12-inch (305-mm) centers.
- D. Where insulated piping is exposed to weather, apply one of the following protective jackets:
 - 1. Over fiberglass insulation:

- a. Aluminum jacket: Apply with an overlap of 4 inches (100 mm) longitudinal and cross-joint seams. Direction of overlap shall prevent entrance of water, with longitudinal joint in horizontal piping 45 degrees down from horizontal. Install jacket tight to insulation and secure in place with aluminum straps at all joints and on minimum 12-inch (305-mm) centers. Coat seams with mastic approved by jacket manufacturer.
 - b. PVC jacket.
2. Over flexible elastomeric insulation: Fully adhere a layer of glass cloth to the insulation surface, with adhesive specified for elastomeric system. Apply two coats of latex enamel finish.

3.90 SCHEDULES

- A. Minimum Thickness Schedule: Thicknesses scheduled are for aboveground, interior piping. See "Installing Exterior Piping Insulation" for additional thicknesses required.

MINIMUM THICKNESS SCHEDULE							
PIPE SIZES (NPS)							
Piping System Types	Fluid Temp. Range (Degrees F)	Equipment Connections Up to 1-1/4 (1)	1-1/2 & less	2	3 to 4	5 & 6	8 and larger
Chilled/Heating water and heating water	120-200	1.5	1.5	2.0	2.0	2.0	2.0
Chilled water	40-55	1.5	1.5	1.5	1.5	1.5	1.5
Refrigerant	0-60	--	1.0	1.0	1.0	1.0	1.5
Refrigerant	120-200	--	1.5	2.0	2.0	2.0	2.0

(1) - Piping within 2 feet of equipment may be insulated with 1.0-inch flexible elastomeric.

END OF SECTION 230719

SECTION 230800 - SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 SUMMARY

- A. Upon completion of all systems startup, testing, adjusting, and balancing by the Contractors, the systems shall be commissioned in the presence of the Owner's representative. The commissioning process shall include final testing and final adjustments.
- B. The Contractors shall be responsible for coordinating the commissioning process to ensure that all necessary personnel including installers and manufacturer's representatives are available on site to assist during the commissioning process. Personnel shall be available to make final adjustments to systems as directed, respond to questions regarding the operation of systems, demonstrate the systems, and train the Owner's personnel to operate and maintain the systems.
- C. The Contractors shall fully cooperate with the Owner during the commissioning process to include adjustments to air and water flow rates and adjustments to the operation of the environmental monitoring and control system to obtain the proper environmental conditions.
- D. Provide additional time and services for commissioning which is required due to system or equipment deficiency.

1.2 DEFINITIONS

- A. Architect: Includes Architect identified in the Contract for Construction between Owner and Contractor, plus consultant/design professionals responsible for design of HVAC, electrical, communications, controls for HVAC systems, and other related systems.
- B. BoD: Basis of Design.
- C. BoD-HVAC: HVAC systems basis of design.
- D. CxA: Commissioning Authority.
- E. OPR: Owner's Project Requirements.
- F. Substantial Completion: Defined in the Conditions of the Contract. When testing specified in 'Testing' in Part 3 below has begun and is proceeding successfully, the Contractor may begin the process to certify Substantial Completion. Commissioning shall be completed before final completion.
- G. Systems, Subsystems, and Equipment: Where these terms are used together or separately, they shall mean 'as-built' systems, subsystems, and equipment.
- H. TAB: Testing, Adjusting, and Balancing.

1.3 CONTRACTOR'S RESPONSIBILITIES

- A. Mechanical contractor:
 - 1. Attend TAB verification testing.
 - 2. Provide measuring instruments and logging devices to record test data, and data acquisition equipment to record data for the complete range of testing for the required test period.

B. HVAC instrumentation and control subcontractor: With the CxA, review control designs for compliance with the OPR and BoD, controllability with respect to actual equipment to be installed, and recommend adjustments to control designs and sequence of operation descriptions.

C. TAB subcontractor:

1. Contract documents review: With the CxA, review the Contract Documents before developing TAB procedures.

a. Verify the following:

- (1) Accessibility of equipment and components required for TAB work.
- (2) Adequate number and placement of duct balancing dampers to allow proper balancing while minimizing sound levels in occupied spaces.
- (3) Adequate number and placement of balancing valves to allow proper balancing and recording of water flow.
- (4) Adequate number and placement of test ports and test instrumentation to allow reading and compilation of system and equipment performance data needed to conduct both TAB and commissioning testing.
- (5) Air and water flow rates have been specified and compared to central equipment output capacities.

D. Electrical contractor:

1. With the mechanical contractor, coordinate installations and connections between and among electrical and HVAC systems, subsystems, and equipment.

1.4 COMMISSIONING DOCUMENTATION

A. Test checklists: CxA shall develop test checklists for HVAC systems, subsystems, and equipment, including interfaces and interlocks with other systems. CxA shall prepare separate checklists for each mode of operation and provide space to indicate whether the mode under test responded as required. Standard checklists developed by organizations, such as AABC Commissioning Group, are acceptable, if items noted below are included. Checklists shall include, but not be limited to, the following:

1. Calibration of sensors and sensor function.
2. Testing conditions under which test was conducted, including (as applicable) ambient conditions, set points, override conditions, and status and operating conditions that impact the results of test.
3. Control sequences for HVAC systems.
4. Strength of control signal for each set point at specified conditions, as recorded by automatic temperature control subcontractor.
5. Responses to control signals at specified conditions.
6. Sequence of response(s) to control signals at specified conditions.
7. Electrical demand or power input at specified conditions.
8. Power quality and related measurements.
9. Expected performance of systems, subsystems, and equipment at each step of test.
10. Narrative description of observed performance of systems, subsystems, and equipment. Notation to indicate whether the observed performance at each step meets the expected results.
11. Interaction of auxiliary equipment.
12. Issues log.

1.5 SUBMITTALS

- A. The following submittals are in addition to those specified in Division 1 Section 'Submittal Procedures.'
- B. Testing Procedures: CxA shall submit detailed testing plan, procedures, and checklists for each series of tests. Submittals shall include samples of data reporting sheets that will be part of the reports.
- C. Certificate of Readiness: CxA shall compile certificates of readiness from each Contractor certifying that systems, subsystems, equipment, and associated controls are ready for testing, as specified in Division 01 and in 'Prerequisites for testing' in Part 3 below.
- D. Certificate of Completion of Installation, Prestart, and Startup: CxA shall certify that installation, prestart, and startup activities have been completed. Certification shall include completed checklists provided by TAB Subcontractor as specified in Division 23 Section 'Testing, Adjusting, and Balancing.'
- E. Certified Pipe Cleaning and Flushing Report: CxA shall certify that pipe cleaning, flushing, hydrostatic testing, and chemical treating have been completed.
- F. Test and Inspection Reports: CxA shall compile and submit test and inspection reports and certificates required by the specifications, and shall include them in systems manual and commissioning report, whether witnessed by the CxA or not.
- G. Corrective Action Documents: CxA shall submit corrective action documents.
- H. Certified TAB Reports: CxA shall submit verified, certified TAB reports.

PART 2 - PRODUCTS

2.1 REPLACEMENTS

- A. CxA will report any defective materials and equipment which become apparent during the commissioning process. The Contractor shall repair or replace defective materials and equipment with specified material and components. This work shall be accomplished at no addition to the Contract Sum.

PART 3 - EXECUTION

3.1 TESTING PREPARATION

- A. Contractor's certification of readiness of systems or parts of the work for testing shall be as required in 'Submittals' in Part 1 above.
 - 1. If CxA begins testing, and finds that the systems or equipment are not ready (false start), the additional cost to restart testing will be charged to the contractor or subcontractor who prepared the certificate of readiness, by the procedures provided in the Contract for changes in the work.
 - 2. Evidence that a system or equipment is not ready: Ten percent of system or equipment is tested and fails to perform requirements.
- B. Prerequisites for testing: Contractors and subcontractors shall:

1. Certify that HVAC systems, subsystems, and equipment have been completed, calibrated, and started; are operating according to the OPR, BoD, and Contract Documents; and that Certificates of Readiness are signed and submitted.
 2. Certify that HVAC instrumentation and control systems have been completed and calibrated; are operating according to the OPR, BoD, and Contract Documents; and that pretest set points have been recorded and labeled in the field.
 3. Certify that TAB procedures have been completed, and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.
 4. Test systems and intersystem performance after approval of test checklists for systems, subsystems, and equipment.
 5. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shut down, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
 6. Verify each operating cycle after it has been running for a specified period and is operating in a steady-state condition.
 7. Inspect and verify the position of each device and interlock identified on checklists. Sign off each item as acceptable, or failed. Repeat this test for each operating cycle that applies to system being tested.
 8. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
 9. Annotate checklist or data sheet when a deficiency is observed.
 10. Verify equipment interface with monitoring and control system and TAB criteria; include the following:
 - a. Supply and return flow rates for VAV and constant volume systems in each operational mode.
 - b. Operation of terminal units in both heating and cooling cycles.
 - c. Minimum outdoor-air intake in each operational mode and at minimum and maximum airflows.
 - d. Building pressurization.
 - e. Total exhaust airflow and total outdoor-air intake.
 - f. Operation of indoor-air-quality monitoring systems.
 11. Verify proper responses of monitoring and control system controllers and sensors to include the following:
 - a. For each controller or sensor, record the indicated monitoring and control system reading and the test instrument reading. If initial test indicates that the test reading is outside of the control range of the installed device, check calibration of the installed device and adjust as required. Retest malfunctioning devices and record results on checklist or data sheet.
 - b. Report deficiencies and prepare an issues log entry.
 12. Verify that HVAC equipment field quality-control testing has been completed and approved. CxA shall direct, witness, and document field quality-control tests, inspections, and startup specified in individual Division 23 Sections.
- C. The percentage of HVAC systems and equipment to be commissioned on this project include:
1. Heating water systems: 100 percent
 2. Chilled water system: 100 percent
 3. Pumping systems: 100 percent
 4. Rooftop air-handling units: 100 percent
 5. Rooftop energy recovery units: 100 percent

6. Air-handling units: 100 percent
7. Dedicated outdoor air systems: 100 percent
8. Variable refrigerant cooling systems: 100 percent of heat rejection equipment, 35 percent of terminal units.
9. Fan-coil units: 35 percent
10. Ductless split systems: 20 percent
11. Exhaust systems: 20 percent

D. The electrical systems to be commissioned on this project include:

1. Emergency generator (Function and power switchover)

E. Testing instrumentation: Install measuring instruments and logging devices to record test data for the required test period. Instrumentation shall monitor and record full range of operating conditions and shall allow for calculation of total capacity of system for each mode of operation. For individual room cooling tests, provide temporary heaters to impose a cooling load indicated in BoD. Operational modes include the following:

1. Occupied and unoccupied.
2. Warm up and cool down.
3. Economizer cycle.
4. Emergency power supply.
5. Life-safety and safety systems.
6. Smoke control.
7. Fire safety.
8. Temporary upset of system operation.
9. Partial occupancy conditions.
10. Special cycles.

3.2 TAB VERIFICATION

A. TAB subcontractor shall coordinate with CxA for work required in Division 23 Section 'Testing, Adjusting, and Balancing.' TAB subcontractor shall copy CxA with required reports, sample forms, checklists, and certificates.

B. HVAC contractor and CxA shall witness TAB work.

C. TAB preparation:

1. TAB subcontractor shall provide CxA with data required for 'Pre-Field TAB Engineering Reports'.

- a. CxA shall use this data to certify that prestart and startup activities have been completed for systems, subsystems, and equipment installation.

D. Ductwork air leakage testing:

1. The HVAC contractor shall supply a copy of the ductwork air leakage testing report, witnessed by TAB subcontractor, as required in Section 23 3113, to the CxA.
2. On approval of ductwork air leakage testing report, the CxA shall coordinate verification testing of ductwork air leakage testing. Verification testing shall include random retests of portions of duct section tests, reported in original ductwork air leakage testing report. The HVAC contractor shall perform tests using the same instrumentation (by model and serial number) as for original testing; the CxA shall witness verification testing.

E. Verification of Final TAB Report:

1. CxA shall select, at random, 10 percent of report for field verification.
2. CxA shall notify TAB subcontractor 10days in advance of the date of field verification; however, notice shall not include data points to be verified. The TAB subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.
3. Failure of an item is defined as follows:
 - a. For all readings other than sound, a deviation of more than 10 percent.
4. Failure of more than 10 percent of selected items shall result in rejection of final TAB report.

F. If deficiencies are identified during verification testing, CxA shall notify the HVAC contractor and Engineer, and shall take action to remedy the deficiency. Engineer shall review final tabulated checklists and data sheets to determine if verification is complete and that system is operating according to the Contract Documents.

G. CxA shall certify that TAB work has been successfully completed.

3.3 TESTING

A. Test systems and intersystem performance after test checklists for systems, subsystems, and equipment have been approved.

1. Contractor shall ensure that each system is ready for testing when tests are schedule, that is, plugged or capped for pressure and leak tests, and similar preparations.

B. Perform tests using design conditions whenever possible.

1. Simulate conditions by imposing an artificial load when it is not practical to test under design conditions and when written approval for simulated conditions is received from CxA. Before simulating conditions, calibrate testing instruments. Set and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
2. Alter set points when simulating conditions is not practical and when written approval is received from CxA.
3. Alter sensor values with a signal generator when design or simulating conditions and altering set points are not practical. Do not use sensor to act as signal generator to simulate conditions or override values.

C. Scope of HVAC Contractor testing:

1. Testing scope shall include entire HVAC installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. It shall include measuring capacities and effectiveness of operational and control functions.
2. Test all operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. Detailed testing procedures: CxA, with HVAC contractor, TAB subcontractor, and HVAC instrumentation and control subcontractor, shall prepare detailed testing plans, procedures, and checklists for HVAC systems, subsystems, and equipment.

- E. Boiler Testing and Acceptance Procedures: Testing requirements are specified in Division 23 boiler Sections. CxA shall review and comment on submittals, test data, inspector record, and boiler certification and shall compile information for inclusion in systems manual.
- F. HVAC instrumentation and control system testing:
1. Field testing plans and testing requirements are specified in Division 23 Controls Section. The CxA, HVAC contractor, and the HVAC instrumentation and control subcontractor shall collaborate to prepare testing plans.
 2. CxA shall convene a meeting of appropriate entities to review test report of HVAC instrumentation and control systems.
 3. Testing shall include both the system at the project site and the related functions of the Owner's operations center.
- G. Pipe cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in Division 23 piping Sections. HVAC contractor shall prepare pipe system cleaning, flushing, and hydrostatic testing. CxA shall review and comment on plan and final reports. CxA shall certify that pipe cleaning, flushing, hydrostatic tests, and chemical treatment have been completed. Plan shall include the following:
1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed Drawings for each pipe sector showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
 2. Description of equipment for flushing operations.
 3. Minimum flushing water velocity.
 4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.
- H. Refrigeration system testing: HVAC contractor shall prepare a testing plan to verify performance of chillers, refrigerant compressors and condensers, and other refrigeration systems. Plan shall include the following:
1. Sequence of testing and testing procedures for each item of equipment and section of pipe to be tested, identified by identification marker. Markers shall be keyed to Drawings showing the physical location of each item of equipment and pipe test section. Drawings shall be formatted to allow each item of equipment and section of piping to be physically located and identified when referred to in the system testing plan.
 2. Tracking checklist for managing and ensuring that all pipe sections have been tested.
- I. HVAC distribution system testing: HVAC contractor shall prepare a testing plan to verify performance of air steam, and hydronic distribution systems; special exhaust; and other distribution systems. Include HVAC terminal equipment and unitary equipment. Plan shall include the following:
1. Sequence of testing and testing procedures for each item of equipment and section of pipe to be tested, identified by identification marker. Markers shall be keyed to Drawings showing the physical location of each item of equipment and pipe test section. Drawings shall be formatted to allow each item of equipment and section of piping to be physically located and identified when referred to in the system testing plan.
 2. Tracking checklist for managing and ensuring that all pipe sections have been tested.

J. Deferred testing:

1. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, the deficiency shall be documented and reported to Owner. Deficiencies shall be resolved and corrected by appropriate parties and test rescheduled.
2. If the testing plan indicates specific seasonal testing, appropriate initial performance tests shall be completed and documented and additional tests scheduled.

K. Testing reports:

1. Reports shall include measured data, data sheets, and a comprehensive summary describing the operation of systems at the time of testing.
2. Include data sheets for each controller to verify proper operation of the control system, the system it serves, the service it provides, and its location. For each controller, provide space for recording its readout, the reading at the controller's sensor(s), plus comments. Provide space for testing personnel to sign off on each data sheet.
3. Prepare a preliminary test report. Deficiencies will be evaluated by Engineer to determine corrective action. Deficiencies shall be corrected and test repeated.
4. If it is determined that the system is constructed according to the Contract Documents, Owner will decide whether modifications required to bring the performance of the system to the OPR and BoD documents shall be implemented or if tests will be accepted as submitted. If corrective work is performed, Owner will decide if tests shall be repeated and a revised report submitted.

END OF SECTION 230800

SECTION 230901 - AUTOMATIC TEMPERATURE CONTROL SYSTEM

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Complete new network-based automatic temperature control (ATC) system with Bacnet protocol.
- B. Sequence of operation for automatically controlled equipment is shown on drawings. ATC subcontractor shall cooperate with the unit suppliers and provide all relays and wiring required to integrate the sequence of operation.

1.12 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Automatic control valves, pressure and flow switches, and insertion wells in piping: For installation under Section 232113.
- B. Dampers: For installation under Section 233113.

1.13 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Duct smoke detectors: Section 283100.

1.14 RELATED SECTIONS

- A. Controls: Sections 230901 through 230923.
- B. Balancing: Section 230593.

1.25 SYSTEM DESCRIPTION

- A. Provide a complete system of direct digital temperature controls with electronic actuation.
- B. The system shall consist of two levels of network communication and wiring, DDC controllers, application-specific controllers, software, operator I/O devices, sensors and other necessary input hardware, dampers, valves, actuators and other necessary output hardware, fire and smoke devices, electrical power surge protection, other necessary equipment and a complete system of wiring to fulfill the intent of the sequences of operation shown on the drawings.

1.26 DESIGN REQUIREMENTS:

- A. The products specified, scheduled, and shown on drawings are the basis of the design of this project.
- B. For requirements affecting use of optional manufacturers, or substitutions, see Division 01 and Section 230101, HVAC General Provisions, and Section 230500, Common Work Results for HVAC.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Contractor qualifications: Submit a list of a minimum of three projects similar to this project in type, size, and duty, which have been operating satisfactorily for not less than five years.

1. Include project name, address, name and phone number of Owner's representative and project size and type.
- C. Shop drawings: Provide a point schedule and composite control diagram of all equipment provided for each control sequence, including factory and field controls. Include a written description of sequences, in which each control device or item of equipment is identified by the designation indicated on the diagram.
- D. Product data: See individual controls sections.
- E. Certifications:
 1. Factory authorization and certification of the installing company.
 2. Evidence of training, and certification of each supervisor and mechanic assigned to this project.
- F. Project record documents: As specified in Division 01 and Section 230101, provide a drawing at the same scale as the contract drawings, showing the locations of all components installed.

1.40 QUALITY ASSURANCE

- A. Subcontractor qualifications: One hundred percent company-owned, full-service, local branch or authorized factory-direct contractor for one of the acceptable national temperature control manufacturing companies named below, as follows:
 1. Full service: Includes system engineering, shop drawing preparation, software programming, installation, commissioning, and service.
 2. Factory-direct contractor: Is contracted directly with manufacturer to buy components and has direct access to manufacturer's local branch office for engineering, service, and technical support without any third-party involvement.
 3. Experience: The branch or factory-direct contractor shall have completed at least three system installations of the same type, size, and design, which have successfully operated their sequence of operations for at least three years.
 4. Supervisors and mechanics: Factory-trained and certified in the type of control system (pneumatic, electric, digital, electronic) being installed, and directly employed by the subcontractor.
 - a. The programmer responsible for programming digital controllers shall have a minimum of three years' experience programming digital controllers of the manufacturer, for HVAC systems.
- B. Qualified subcontractor shall prepare control diagrams.
- C. Perform work in accordance with the plumbing, electrical, building, fire and safety codes of the state, county, or city in which the work is performed.
- D. UL label and local testing (if required): As specified in Section 230500, Common Work Results for HVAC.

1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a commissioning agent. Contractor's and subcontractor's responsibilities are described in Division 01.
- B. Cooperate with the commissioning agent to accomplish the requirements of the commissioning plan during construction and correction period.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Direct digital system:
 - 1. Johnson Controls, Inc.; Baltimore Office
 - 2. Siemens Building Technologies, Inc. - Landis Div.; Baltimore Office
 - 3. Honeywell, Inc.; Baltimore Office

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Coordinate with equipment suppliers to integrate controls provided by manufacturers into the control sequences shown on drawings.
- B. Mount devices and control panels provided by equipment manufacturers, and provide required control wiring.
- C. Operate, test, calibrate, and adjust each control system until it operates as intended by the manufacturer and as specified in the control sequence.

3.61 TESTS

- A. Thoroughly test and check the completed system to ascertain that all equipment is functioning as intended and that dampers and valves respond properly to their controls. Installer of work of this section shall cooperate with the equipment suppliers, and with balancing and testing work, to make necessary adjustments to ATC devices for proper operation of the completed system.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 230500, provide operating instructions.
- B. Provide at least eight hours of additional instruction time for the system specified in this section, consisting of two periods of 4 consecutive hours, separated by at least 30 days.

END OF SECTION 230901

SECTION 230902 - CONTROL SYSTEMS WIRING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Wiring for automatic temperature control system.

1.14 RELATED SECTIONS

- A. Automatic temperature control system: Sections 230901 through 230923.
- B. Control sequences: Shown on drawings.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: Wire, cable, conduit and fittings, disconnecting switches, and transformers.

1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 230500, Common Work Results for HVAC.
- B. ATC circuit shall not supply other building components such as lights or receptacles.

PART 2 - PRODUCTS

2.10 MATERIALS, GENERAL

- A. Electrical materials and devices shall be UL listed and shall meet the requirements of NEC (NFPA 70) and Division 26, Electrical.

2.21 WIRING

- A. Wiring 50 V and below: Fully color coded, copper 600 V type THW or THHN, minimum No. 22 or as specified in Division 16, Electrical.
- B. Wiring above 50 V: As specified in Section 260519, Wires and Cables.

2.22 CONDUIT AND FITTINGS

- A. Galvanized steel conduit: Minimum size 0.5 inch (16 mm), hot-dip galvanized with threads galvanized after cutting, one of the following:
 - 1. Rigid full weight, heavy-wall steel conduit (RGS) conforming to UL 6 and ANSI C80.01.
 - 2. Intermediate steel conduit (IMC) conforming to UL 1242 and ANSI C80.03.
- B. Steel conduit fittings: Cast malleable iron fittings with smooth finish and full threaded hubs. Include steel or malleable iron locknuts, bushings, and other fittings.
 - 1. Insulating bushings: Equal to Thomas and Betts Series 22.

2. Hub fittings with recessed sealing ring and nylon insulated throat equal to Thomas and Betts Series 370.
 3. Fittings for exposed locations: Conduit outlet bodies, zinc- or cadmium-plated.
- C. Electrical metallic tubing (EMT): Minimum size 0.5 inch (16 mm), maximum 1.5 inch (41 mm), hot-dip galvanized or sherardized thin-wall steel conduit conforming to UL 797 and ANSI C 80.03.
- D. Connectors and couplings for EMT: Concrete- or rain-tight, compression or set screw type, made of cadmium-plated steel with nylon insulating throat, equal to Thomas & Betts Series 5031, 5123 and 5120.
- E. Flexible metal conduit: Minimum size 0.5 inch (16 mm), made of sheet metal strip, interlocked construction, conforming to UL 1.
- F. Liquidtight flexible metal conduit shall conform to UL 360.
- G. Connectors for flexible metal conduit: Equal to angle wedge "Tite-Bite" with nylon insulated throat, Thomas & Betts Series 3110 and 3130.
- H. Liquidtight connectors: UL 14814A, with fittings and nylon-insulated throat, equal to Thomas & Betts Series 5331.
- I. Surface metal raceway: Equal to Wiremold No. 700 minimum size, complete with fittings, connectors, and accessories.

2.30 EQUIPMENT

- A. Control transformer: Designed for power sources for 24-V ac control circuits, and precision built to ensure rated power, proper voltage regulation and maximum efficiency. Units shall be equipped with integral manual reset circuit breaker for over-current protection on the secondary winding. Output regulation shall be 10 percent from no load to full load.
- B. Disconnecting switches: Specified in Section 262800.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Electrical equipment is specified in Division 26, Electrical. Include in the work of this section relays, pushbuttons, transformers, coils, power wiring, control wiring, or other equipment, meeting requirements of Division 16, so that the automatic temperature control system will function as specified and indicated on the drawings.
- B. Do not use equipment power supply as source for ATC power. Provide a circuit breaker in an electrical panelboard to make ATC connection.
1. Provide circuit breakers that match and are compatible with the other breakers in the panelboard.
 2. Panelboards dedicated to computer systems are available. Connect ATC to dedicated panelboards.
- C. Install conduit and wiring as specified in Sections 260519 and 260533.

- D. Provide data systems, including outlets, cabling, and required infrastructure, to support the manufacturer's requirements. All data system components shall meet the requirements of Division 27.
- E. Make each run of cable or conductor connecting two points with a single continuous piece of cable or conductor. Do not splice. Cable or conductor may be extended by use of suitable connectors if approved by the Architect.
- F. When connecting to electrical wiring of equipment provided with pilot lights, connect to circuit so that pilot light is energized only when equipment is energized.
- G. Where necessary to connect conduit to motors or motor-driven equipment, or to attach conduit to fan housings or units which contain fans, use a 24-inch (610-mm) looped section of flexible metallic conduit.
- H. When connecting to electric wiring of exhaust fans with Hand/Off/Automatic (HOA) switches and exhaust dampers, connect to circuit so that damper opens in both Hand and Automatic positions.
- I. Securely attach disconnecting switches and starters to the wall with lead anchors.

END OF SECTION 230902

SECTION 230905 - CONTROL PANELS

PART 1 - GENERAL

1.11 SECTION INCLUDED

- A. Control panels and accessories.

1.14 RELATED SECTIONS

- A. General information: Section 230901.
- B. Control sequences: Shown on drawings.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: Each type of control panel included in the project.
- C. Shop drawings: Front elevation of each control panel, drawn at a scale of 0.5 inch equals one foot.
- D. Samples: Color chips, showing complete line of colors and textures.

1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 230500, Common Work Results for HVAC.
- B. Do not begin fabrication of control panels until shop drawings have been approved.

PART 2 - PRODUCTS

2.33 MECHANICAL ROOM CABINETS

- A. Provide enclosed, lockable, 16 gage steel cabinets, one located in each mechanical equipment room, which shall contain all controls which are not required to be mounted at the controlled device. Manual switches and indicating gages for each switch shall be mounted inside the cabinet. Wiring and tubing in the panel shall be color-coded, and wiring shall be extended to numbered terminal strips.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Panels mounted on legs shall have the legs securely attached to floor with 0.25 inch lead anchors. Provide a 4-inch-high concrete base around legs and conduits leaving the panel where conduits pass into floor.
- B. Panels attached to walls shall be secured with toggle bolts or lead anchors as required. Anchor plates shall be built into walls for large surface-mounted units.

END OF SECTION 230905

SECTION 230907 - CONTROL DAMPERS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Dampers for automatic control.

1.12 PRODUCTS SUPPLIED BUT NOT INSTALLED UNDER THIS SECTION;

- A. Dampers: Install under Section 233300.

1.14 RELATED SECTIONS

- A. Smoke detectors: Section 283100.
- B. Ductwork: Section 233113.
- C. Fire dampers and smoke dampers: Section 233300.
- D. Control system, general: Section 230901.
- E. Control sequences: Shown on drawings.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data, including test data and ratings, for each type of damper and operator included in the work.

PART 2 - PRODUCTS

2.21 CONTROL DAMPERS AND OPERATORS

- A. Supply and return dampers: Equal to Ruskin Model CD35. Dampers for two-position control may be parallel blade type. Dampers for modulating control shall be balanced, multi-louver, opposed-blade type.
 - 1. Blades: Interlocking, minimum 16 gage galvanized steel. Maximum blade width: 8 inches (205 mm). Maximum blade length: 48 inches (1220 mm) without intermediate bearing and frame stiffener.
 - 2. Frames: Dampers shall be mounted horizontally in a welded channel angle or flat steel frame filled with solid air-stops which shall prevent air leakage between frame and blades. Provide corner braces on frames that measure more than 24 by 24 inches (610 by 610 mm). Finish: two coats of black enamel.
 - 3. Operation: Provide blades with brass pivots operating in non-stick, corrosion-resistant bearings securely mounted in damper frames. Hardware and operating linkage shall be brass or cadmium plated steel. Linkage shall be adjustable in length; joints shall be pin and clevis or ball and socket, free of excessive play. Dampers shall be capable of being positioned accurately from 100 percent open to 100 percent closed and of maintaining any given position indefinitely. Dampers requiring 100 percent closure shall have neoprene gasketed edges.

- B. Outdoor air (OA), pressure relief (PR), and exhaust air (EA) dampers: Equal to Ruskin CD 50 low-leakage damper, AMCA-rated Class 1 in accordance with AMCA 511, leakage no more than 4 cfm per square foot at 1-inch wg when tested in accordance with AMCA 500D.
 - 1. Blades: Interlocking, minimum 0.125- inch (3.2-mm) thick extruded aluminum, airfoil shape, maximum width 6 inches.
 - a. Dampers for two-position control: May be parallel-blade type.
 - b. Dampers for modulating control: Opposed-blade type.
 - 2. Frames: Minimum 0.125-inch (3.2-mm) thick extruded aluminum, with provisions for mounting.
 - 3. Edge seals: Inflatable, replaceable, double-edge blade seal, mechanically held. Flexible metal frame seal.
 - 4. Operation: Linkage out of airstream, axles 0.5-inch (13-mm) diameter and hexagonal, molded synthetic bearings.
- C. Electric damper operators: Electric motor type with opening time of at least 30 seconds, of size to have 50 percent more power than the minimum required to operate the damper. Fail safe in the event of loss of power: Fresh air and exhaust air dampers shall close and return air dampers shall open.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Furnish dampers to be set in place under Section 233113, Metal Ducts, under the supervision of the control subcontractor.
- B. Install operators on control dampers. Operation of particular dampers in conjunction with operation of air-handling equipment is described in control sequences.
- C. Set screws shall be set on a flat space on a round shaft. Provide a double set screw as a lock.

END OF SECTION 230907

SECTION 230908 - CONTROL VALVES

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Automatic control valves, actuators, and accessories.

1.12 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Control valves: Section 232113.

1.14 RELATED SECTIONS

- A. Control system, general: Section 230901.
- B. Control sequences: Shown on drawings.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: Valves, devices, and actuators, each type included in project.

PART 2 - PRODUCTS

2.21 CONTROL VALVES

- A. Two-way and three-way valves shall be sized by the control subcontractor and guaranteed to be of sufficient size to meet the heating or cooling requirements.
- B. With no electric power on the valve actuator, valve shall be in the normal position determined by the application.
 - 1. Unless indicated otherwise, valves serving heat pump unit compressors are normally open to allow full flow to compressors.
- C. Valves NPS 2 (DN 50) and smaller: Characterized equal percentage ball valve, capable of handling water at a maximum 150 psig (1035 kPa), 281 degrees F (138 degrees C). Valves shall have threaded ends.
 - 1. Bodies: Cast brass, rated at 150 psig (1035 kPa).
 - 2. Trim: Brass.
 - 3. Stem: Stainless steel, with replaceable composition disk seat. The stem packing shall be synthetic elastomer U-copper type, utilizing the system pressure to prevent packing leaks.
- D. Valves NPS 2.5 (DN 65) and larger: Single-seated with equal percentage flow characteristic valve plug.
 - 1. Bodies: Cast iron, rated 150 psig (1035 kPa).
 - 2. Trim, stem, replaceable disk, and stem packing: The same as the smaller valves.
- E. Three-way valve: Mixing or diverting for modulating or two-position control of the direct-or reverse-acting type with maximum operating temperature of 250 degrees F (121 degrees C).

1. Bodies: Brass or bronze, rated at 150 psi (1034 kPa), with threaded end connections or cast iron rated at 150 psi (1034 kPa) with flanged end connections .
 2. Trim: Bronze or brass.
 3. Stem: Stainless steel with replaceable bronze or brass seat. The stem packing shall be silicone U-copper Teflon V ring.
- F. High performance butterfly valves: Two-way or three-way modulating for position control of the mixing or diverting applications. Three-way assemblies shall be assembled with two valves and a flanged cast-iron tee, or dual valve pipe assemblies. Valve body shall be supplied with stainless steel stem, bronze or steel disk and synthetic rubber seat. Valve shall be suitable for electric actuation. Valves shall be rated for 150 psi (1034 kPa) and 225 degrees F (107 degrees C).
- G. Maximum pressure drop across water control valves shall be 2.0 psi (14 kPa). Isolation type control valves shall be equal to pipe size, unless pressure drop exceeds 2.0 PSF.

2.23 ELECTRIC VALVE OPERATORS

- A. Low or line voltage electric or electronic motor type with minimum opening and closing time of 15 seconds, sized to provide sufficient power to operate the valve, and for full shutoff against the operating pressure.
- B. Solenoid valves (quick-closing) are not acceptable.

PART 3 - EXECUTION

3.21 INSTALLING VALVES

- A. Install valves complete with operators, as indicated on drawings and as required by Control Sequences.

END OF SECTION 230908

SECTION 230913 - INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Control devices and accessories.

1.12 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Wells: Section 232113.
- B. Flow switches: Section 232113.
- C. Differential pressure switches: Section 232113.

1.13 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Duct-mounted smoke detectors: Section 283100.

1.14 RELATED SECTIONS

- A. Automatic temperature control system: Sections 230901 through 230923.
- B. Sequence of operations: Shown on drawings.
- C. DDC flow meters: Section 230519.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Shop drawings:
 - 1. Each control device labeled with setting or adjustable range of control.
 - 2. Wiring diagrams. Differentiate between factory-installed and field-installed wiring.
- C. Product data:
 - 1. For each device, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes, and installation instructions.
 - 2. Each type of accessory. Include finishes.
- D. Maintenance data: As required in 230101, HVAC General Provisions.

1.90 MAINTENANCE

- A. Provide two sets of manufacturer's special tools for operating tamperproof fasteners, marked to identify their use.
- B. Calibration kit for carbon dioxide sensors: Portable, for field calibration, including nitrogen gas, tubing, regulator, and case, with manufacturer's instructions for performing calibration.
- C. Deliver maintenance products to Owner's designated storage area and store as directed.

- D. Maintenance service: On Substantial Completion and building occupancy, calibrate carbon dioxide sensors and instruct Owner's personnel in the procedure.

PART 2 - PRODUCTS

2.10 CONTROL DEVICES, GENERAL

- A. Instruments with predetermined temperature or pressure setpoints shall be provided with a means of adjustment over a reasonable range. Adjustable devices for control of temperatures shall be graduated and calibrated in degrees F. Markings such as WARMER and COOLER are not acceptable.
- B. Devices mounted outdoors shall be weathertight construction or mounted in weathertight enclosure or inside weathertight units.

2.13 DIGITAL CONTROLS (ELECTRONIC)

- A. Each room temperature sensor shall include a setpoint adjustment dial, and a terminal jack.
 - 1. The setpoint adjustment dial shall allow for modification of the temperature by the occupant. Setpoint adjustment may be locked out, overridden or limited as to time or temperature through software by an authorized operator.
 - 2. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller.
 - 3. Provide controller to accommodate sensor type. Provide room temperature sensors closely matched to the requirements of the associated controllers. Signal input and output shall be accurate, responsive, and silent. The sensor may be either RTD or thermistor type providing the following minimum performance requirements are met:

Accuracy: plus or minus 1 degree F (0.6 degrees C)

Operating range: 35 to 115 degrees F (2 to 46 degrees C)

Set point adjustment range: 55 to 95 degrees F (2 to 30 degrees C)

Set point modes: Independent Heating, Cooling, Night Setback-Heating, Night Setback-Cooling

Calibration adjustments: None required

Installation: Up to 100 feet from controller

- B. Humidity sensors: Range shall be 10 to 90 percent RH with ± 2 percent RH accuracy; wall mounted or insertion type as required by the installation.
- C. Enthalpy sensors: Sensing element shall be combination bimetal/nylon. Span shall be 24 BTU/lb. dry air. Range shall be 16 to 40 BTU/lb. dry air. Units shall be suitable for duct mounting.
- D. Carbon dioxide sensors: Wall or duct insertion type, 0-2000 ppm range, typical accuracy of ± 30 ppm or ± 2 percent of reading between 60 and 90 degrees F, 0-10 VDC or 4-20 mA output, less than 5 percent drift over 5 year calibration interval; equal to Vaisala GMD20. Wall-mounted units shall be furnished with blank-off cover for LCD display with separate tamperproof wire guard.

- E. Static pressure sensors:
 - 1. Duct static pressure sensors shall be of the solid-state diaphragm type with integral 2-wire, 4-20 mA signal conditioning and high and low adjustments. Range shall be 0-5 inches wg; output shall be 4-20 mA. Accuracy shall be 0.025 percent per degree C maximum over a temperature sensitivity range of 25 to 75 degrees C.
 - 2. Space pressure sensor: Solid-state, temperature compensated piezoresistive balanced bridge 4-20 mA output, minus 0.25 to plus 0.25 inch wg range, ± 0.02 percent at 77 degrees F accuracy, ± 0.2 percent drift/year stability.
- F. Differential pressure sensing in piping: Pressure sensors for control of variable frequency drives on pumping systems shall be of the solid-state type with NEMA 250 Type 1 cast aluminum housing. The static error band shall not exceed ± 0.5 percent of full scale. The operating temperature range shall be minus 40 to plus 200 degrees F and shall be temperature compensated. Zero and span adjustments shall be accessible externally. The output shall be 4-20 mA. Provide three-valve manifold for each sensor.
- G. Sensors installed in pipes shall be installed in thermometer wells of bronze or stainless- steel materials. Heat transfer compounds shall be compatible with the sensor. Compression type fittings between sensors and thermometer wells are not acceptable.
- H. Temperature sensors for air systems shall be RTD type. Sensors shall have a time constant response of less than 3 seconds to a temperature change of 1 degree. Sensors shall be coupled with industrial grade adjustable span transmitters to achieve the following range with the accuracy specified: 10 to 100 degrees F, plus or minus 1 degree F. Sensors shall be suitable for insertion into air ducts and have a minimum insertion of 6 inches.
- I. Condensate overflow switches: Sensor/switch to be installed in secondary condensate pans to detect clogged drains, equal to Grainger 3XY17.

2.14 AUXILIARY CONTROLS

- A. Timers: Spring-wound type with automatic return, the number of hours setting as indicated in sequence of operations, time indicating dial, mounted in flush box. Provide engraved plastic nameplate, white letters on black background, for each timer.
- B. Emergency fan disconnecting switch:
 - 1. Switch: Security type, operated by a keyed lock, with stainless-steel device plate, equal to The Knox Company KS-2. All emergency fan disconnect switches in the project shall be keyed alike.
 - 2. Key box: Provide one key in the Owner's "Knox Box" installed near the main entry doors, and one spare to the Owner. Provide each key with a permanently fastened metal or plastic tag as specified for identification in Section 230500, engraved "Emergency Fan Disconnect Switch".

2.22 AIRFLOW MEASURING STATIONS (AMS)

- A. AMS applications:
 - 1. Provide AMS nested in fan inlets as indicated on the ATC drawings.
 - 2. AMS may be either vortex shedding type or thermal dispersion type.

- B. Each AMS shall include a fan- or duct-mounted airflow sensor assembly and a remote airflow transmitter.
- C. Available manufacturers:
 - 1. Vortex shedding type: Equal to Tek-Air "Vor Tek" Model VT5000 in supply, return and exhaust ducts and model VT 7000 min fan inlets.
 - 2. Thermal dispersion type: Equal to Ebtron "Gold Series" units.
- D. Total installed system accuracy: Within 3 percent of actual flow, including sensor and transmitter accuracy.
- E. Probes: Sensors at concentric area centers across the duct or fan opening and mounted on a structural grid or manifold.
 - 1. Fan inlet probes: Include dual end support brackets suitable for mounting in the fan inlet bell, and symmetrical averaging signal takeoffs and fittings.
 - 2. Probes shall not induce a measurable pressure drop.
 - 3. Probes shall not cause amplification of system sound.
 - 4. Signals: Steady, non-pulsating without need for flow corrections or factors.
- F. Electronic flow transmitters: Industrial process control type, capable of receiving signals from the airflow measuring device, of amplifying, extracting the square root, and scaling to product at 4-20 ma DC OR 0-5 VDC output signal linear and scaled to air volume or velocity.
 - 1. Transmitters shall include an integral digital LED display for configuration and calibration, and to display one transmitter output during normal operating mode. Input pushbuttons shall provide means to perform transmitter configuration, parameter setting, zero and span calibration, and display formatting and scaling via the on-board microprocessor. Transmitters shall be equal to Air Monitor Veltron II NEMA 250 Type I enclosure in compliance with the following criteria.
 - a. Reference accuracy: Plus or minus 0.1 percent of natural span (including non-linearity, hysteresis, and non-repeatability)
 - b. Zeroing: Automatic, within 0.1 percent of operating span.
 - c. Temperature stability: 0.015 percent of full span per degree F. No zero effect.
 - d. Power supply: 24 VAC or 24 VDC, selectable.
- G. Operation:
 - 1. Unit factory-calibrated.
 - 2. Total installed system accuracy: 3 percent of actual airflow, including sensor and transmitter accuracy and sensor location.
 - 3. Sensing ranges:
 - a. Temperature: -20 to 160 degrees F (-28.9 to 71.1 degrees C).
 - b. Humidity (non-condensing): 0 to 99 percent.
 - c. Pressure drop: Less than 0.005 inch wg at 2000 fpm.
 - 4. Flow measurement drift during the lifetime of the equipment shall not exceed manufacturer's repeatability statement.
 - 5. AMS shall compensate for temperature and humidity.

2.70 ACCESSORIES

- A. Guards for wall-mounted thermostats, sensors, or other control devices: Size selected to suit device to be protected, designed for vertical or horizontal mounting.
 - 1. For locations accessible to the public, including classrooms, or provided with line voltage thermostats: Equal to Kele TG500 Series, double-wall cover, steel with manufacturer's standard white enamel finish, with wall plate, base, lock, and two keys.
 - 2. For locations in utility spaces: Equal to Kele AT1104, cast aluminum with openings on front and all sides, designed for mounting directly to wall.
 - 3. Fasteners: Tamperproof. Include 2 sets of special tools as required in Part 1 above.
 - 4. Administrative office areas shall not be considered "public space" as it relates to the requirement for guards.

- B. Plastic nameplates: As specified in Section 230500, Common Work Results for HVAC, minimum plate size 0.75 by 2.5 inches, minimum letter size 0.1875 inch, properly identifying equipment and use.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Where averaging type bulbs or tubing and low temperature protection thermostats are installed within ductwork or unit casings, provide a removable galvanized frame with 1-inch square mesh wire for attaching the tubing in desired pattern. Where capillary passes through duct side or unit casing, provide split flange fitting to seal hole and protect the capillary in the duct or casing.

- B. Instruments mounted on insulated ducts or equipment shall have mounting brackets arranged to permit full insulation on the duct.

- C. Room thermostats or temperature sensors mounted in unit casing or on sampling chamber shall not be an acceptable substitute for insertion thermostats.

- D. One-pipe transmitters may be used in insertion and immersion thermostat applications only as a sensing element for a receiver-controller.

- E. Bulbs for outdoor air thermostats or temperature sensors shall be shielded from the sun and reflected heat rays. These bulbs may be located behind weather louvers of OA intakes but ahead of any ATC damper.

- F. Special-purpose instruments, such as timer switches or other appurtenances shall be provided with engraved nameplates which properly identify the items. Nameplates shall be mounted with vandalproof screws on the wall immediately below the item.

- G. Thermostats, temperature sensors, humidity sensors and carbon dioxide sensors. Mount on wall, securely anchored. Mounting height from floor to top of device shall be 48 inches, as required for accessibility to persons using wheelchairs.

- H. Mount wall-mounted devices with tamperproof screws. Where devices are located in new locations, use wall boxes securely anchored flush into the wall. Use copper tubing from ceiling to device either fished through wall cavity or chased into wall and patched to match existing surface.

- I. Provide guards for all wall-mounted devices, including thermostats, temperature sensors, humidity sensors, and carbon dioxide sensors.
 - 1. Mount guard base to wall by at least four tamperproof screws, entirely independent of device wall plate and cover.
- J. Provide manual override on thermostats or temperature sensors as noted in sequence of operation.
- K. Emergency fan disconnect switch: Install in location approved by Fire Marshal.

3.21 INSTALLING DIGITAL CONTROLLER

- A. Provide wiring required between digital controller and equipment as scheduled on the Control Point Schedule.
- B. Cooperate with Owner to set up the digital controller to operate as shown in sequence of operations on the drawings.

3.70 ADJUSTING

- A. Calibrate carbon dioxide sensors: Perform zero and span calibrations, following manufacturer's recommended procedures.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 230500, provide operating instructions.
- B. Instruct Owner's personnel in use of calibration kit to perform annual calibration of carbon dioxide sensors.

END OF SECTION 230913

SECTION 230923 - DIRECT DIGITAL BUILDING SYSTEMS CONTROL

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Direct digital building control (DDC) system.
- B. Network communications
- C. DDC panels
- D. System software
- E. Application-specific controllers
- F. Operator I/O Devices

1.14 RELATED SECTIONS

- A. Coordination, installer qualifications, and acceptable manufacturers: Section 230901.
- B. Automatic temperature control system: Sections 230901 through 230923.
- C. Control sequences: Shown on drawings.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Installer qualifications: Submit as required in Section 230901, Automatic Temperature Control System. Include, in addition to other requirements, the location of the support facility from which warranty and service will be provided, and a list of the names, titles, and training of the individuals who will be responsible for the work of this project.
- C. Documentation: Submit complete documentation for the system hardware and software, including user's manuals and other support sufficient to enable Owner's personnel to understand and correctly operate the system. Include this documentation in Operation and Maintenance submittals in accordance with Division 01 and Section 230101.
- D. Certifications:
 - 1. Data sheet or copy of government approval form showing that the system complies with FCC Regulations, Part 15, Section 15.
 - 2. Results of functional and diagnostic field tests and calibrations, specified in Part 3. Submit copies of the installing technician's checklist showing that the system has been completely set up and is ready to operate.
 - 3. Submit Compliance Inspection Checklist, initialed and dated, showing satisfactory completion of the installation tests specified in Part 3.

1.90 WARRANTY AND SERVICE

- A. General requirements: Provide all services, materials and equipment necessary for the successful operation and maintenance of the entire DDC system for the period of the general project correction period required by General Conditions, Division 01, and Section 230101. Provide parts, software, and labor required for the work. Schedule maintenance and adjustments to minimize effects on facility operations.
- B. The adjustment and repair of the system includes computer equipment, software updates, transmission equipment, and sensors and control devices. Provide the manufacturer's required adjustments and other work necessary to maintain system operation.
- C. Personnel: Provide qualified personnel to accomplish work promptly and satisfactorily. Notify Owner in writing of the name of the designated service representative, and of changes in personnel.
- D. Schedule of work: Schedule major inspections in June and December and minor inspections in March and September. Minor inspections shall include visual checks and operational tests of each item of equipment. Major inspections shall include all work described for minor inspections and the following work:
 - 1. Clean equipment, including interior and exterior surfaces.
 - 2. Perform signal, voltage, and system isolation checks of system workstations and peripherals.
 - 3. Check and calibrate each field device. Check all analog points and digital points.
 - 4. Run diagnostics and correct diagnosed problems.
 - 5. Resolve and correct other observable problems.
- E. Emergency service: Qualified personnel shall be available to provide service to the complete system. Furnish owner with a telephone number where service representative can be reached at all times. Service personnel shall be at the site within 8 hours after receiving a request for service, and shall restore the control system to proper operating condition within 24 hours.
- F. Operation: Performance of scheduled adjustments and repair shall verify operation of the system as demonstrated by the initial performance test.
- G. System modifications: Make recommendations for system modification in writing to Owner. Do not make any system modifications, including operating parameters and control settings, without prior written approval of Owner. Modifications to the system shall be incorporated into the operations and maintenance manuals and other documentation.
- H. Software: During the project correction period, provide all software updates and verify operation in the system in a timely manner. Instruct the system operators, and incorporate updates into the operations and maintenance manuals and software documentation. At the end of the correction period, continue to notify Owner of software revisions.

PART 2 - PRODUCTS

2.30 GENERAL PRODUCT DESCRIPTION

- A. The DDC system shall integrate multiple building functions including equipment supervision and control, alarm management, energy management, and historical data collection.

- B. The building control system shall include the following:
 - 1. Network DDC panels
 - 2. Network application-specific controllers (ASCs)
 - 3. Portable operator's terminals
 - 4. Personal computer operator workstation(s)
- C. The system shall be modular and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC panels, application-specific controllers, and operator devices.
- D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC panel shall operate independently by performing its own specified control, alarm management, operator I/O, and data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
- E. Without depending on a control processing device, DDC panels shall be able to:
 - 1. Access any data from or send control commands and alarm reports directly to any other DDC panels or combination of panels on the network.
 - 2. Send alarm reports to multiple operator workstations.

2.31 NETWORKING COMMUNICATIONS

- A. The DDC system shall network operator workstations.
 - 1. A high performance peer-to-peer network.
 - 2. An application-specific local area network (LAN).
- B. Peer-to-peer network level:
 - 1. Operator workstations and DDC panels shall directly reside on a network such that communications shall be executed directly between DDC panels, directly between workstations, and between DDC panels and workstations on a peer-to-peer basis.
 - 2. Inherent in the system's design shall be the ability to expand or modify the network either via a LAN, or auto-dial telephone line modem connections, or via a combination of the two networking schemes.
 - 3. All operator devices, either network-resident or connected via modems, shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the peer-to-peer network. Access to data shall be based on logical identification of building equipment. No hardware or software limits shall be imposed on the number of devices with global access to the network data.
 - 4. Network design shall include the following provisions:
 - a. Provide high-speed data transfer rates for alarm reporting, quick report generation from multiple controllers and upload/download efficiency between network devices. An alarm occurring at any DDC panel shall display at one or more workstations or alarm printers within 5 seconds.
 - b. Support of any combination of DDC panels and operator workstations directly connected to the peer-to-peer network. The network shall support a minimum of 32 devices.
 - c. Message and alarm buffering to prevent information from being lost.
 - d. Error detection, correction, and retransmission to guarantee data integrity.

- e. Synchronization of real-time clocks, to include automatic daylight savings time updating among all DDC panels.
 - f. Commonly available, multiple source, networking components and protocols shall be used to allow the DDC system to coexist with other networking applications such as office automation. ETHERNET and ARCNET are acceptable technologies.
 - g. Use of an industry standard IEEE 802.x protocol. Communications must be of a deterministic nature to assure calculable performance under worst-case network loading.
- C. Application-specific local area network (LAN):
- 1. This level communication shall support a family of application-specific controllers and shall communicate bidirectionally with the peer-to-peer network through DDC panels for transmission of global data.
 - 2. Application-specific controllers shall be arranged on the LANs in a functional relationship with DDC panels. For example, a VAV terminal unit controller shall be on a LAN from the DDC panel that is controlling its corresponding AHU.
 - 3. A maximum of 32 application-specific controllers may be configured on each LAN.
- D. Communication capability:
- 1. Automatic communications shall allow DDC panels to communicate with remote operator stations and remote terminals, as indicated in the sequence of operations.
 - 2. DDC panels shall automatically communicate with workstations to report alarms or other significant events.
 - 3. Operators at the workstation shall be able to perform all control functions, all report functions, and all database generation and modification functions as described for workstations connected via the network. Routines shall automatically answer communications from remote DDC panels. The fact that communications are taking place with remote DDC panels shall be invisible to an operator.
 - 4. Communications shall use a standard web browser via local area network..

2.32 DDC PANEL

- A. Microprocessor-based panels with a minimum word size of 16 bits: Multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Each DDC panel shall be capable of operating as a stand-alone controller, performing its specified control functions independently of other controllers in the network. Controller size shall be sufficient to fully meet the requirements of this specification and the point list on the drawings.
- B. Each DDC controller shall have sufficient memory, a minimum of 1 megabyte, to support its own operating system and databases, including:
- 1. Control processes
 - 2. Energy management applications
 - 3. Alarm management applications
 - 4. Historical and trend data for points specified
 - 5. Maintenance support applications
 - 6. Custom processes
 - 7. Operator I/O
 - 8. Communications
 - 9. Manual override monitoring
- C. Each DDC panel shall support:

1. Monitoring of the following types of inputs, without the addition of equipment outside the DDC panel:
 - a. Analog inputs
 - (1) 4-20 mA
 - (2) 0-10 Vdc
 - (3) Thermistors
 - (4) 1000-ohm RTDs
 - b. Digital inputs
 - (1) Dry contact closure
 - (2) Pulse accumulator
 - (3) Voltage sensing
 2. Direct control of electronic actuators and control devices. Each DDC panel shall be capable of providing the following control outputs without the addition of equipment outside the DDC panel:
 - a. Digital outputs
 - (1) Contact closure (motor starters, sizes 1-4)
 - b. Analog outputs
 - (1) 0-20 psi
 - (2) 4-20 mA
 - (3) 0-10 Vdc
- D. Additional space for future point connections, each DDC panel: Minimum 10 percent.
1. Provide sufficient internal memory for the specified control sequences with at least 25 percent of the total memory available for future use.
- E. Each DDC panel shall have at least two RS-232C serial data communication ports for operation of operator I/O devices.
- F. Each DDC panel shall have point discrete, on-board, limited access Hand/Off/Auto operator override switches for digital control type points and gradual switches for analog control type points. These override switches shall be operable whether the panel processor is operational or not. DDC panels shall monitor the status of all overrides and remotely report each override control operation.
- G. DDC panels shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. Status indication shall be visible without opening the panel door.
- H. Each DDC panel shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components, and provide both local and remote annunciation of detected component failures, low battery conditions, or repeated failure to establish communication.

- I. Provide isolation at each peer-to-peer network termination and each field point termination, to suppress induced voltage transients, meeting requirements of IEEE C62.41.
- J. In the event of the loss of normal power, each DDC panel shall shut down in an orderly process which shall prevent the loss of database or operating system software. Provide nonvolatile memory for critical controller configuration data and battery backup sufficient to support the real-time clock and volatile memory for a minimum of 72 hours.
 - 1. Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual intervention.
 - 2. Should DDC panel memory be lost for any reason, reloading the DDC panel shall be possible via the local RS-232C port, via telephone line dial-in, or from an operator workstation.
- K. Provide a DDC panel for each AHU or other HVAC system as indicated on the drawings. It is intended that each unique system be provided with its own point-resident DDC panel.

2.33 SYSTEM SOFTWARE

A. General:

- 1. Provide all necessary software to form a complete control system as described in this specification.
- 2. The software programs specified in this section shall be integral in DDC panels and shall not be dependent upon any higher-level computer for execution.

B. Control software:

- 1. The DDC panels shall have the ability to perform the following pre-tested control algorithms:
 - a. Two-position control
 - b. Proportional control
 - c. Proportional plus integral control
 - d. Proportional, integral, plus derivative control
 - e. Control loop tuning
- 2. Include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.
- 3. Shall protect against excessive demand during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.
- 4. Upon the resumption of normal power, the control software shall analyze the status of controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operations.

C. DDC panels shall be able to perform any or all of the following energy management routines:

- 1. Time-of-day scheduling
- 2. Calendar-based scheduling
- 3. Holiday scheduling
- 4. Temporary schedule overrides
- 5. Start-stop time optimization
- 6. Automatic Daylight Savings Time switchover
- 7. Night setback control
- 8. Enthalpy switchover (economizer)
- 9. Peak demand limiting

10. Temperature-compensated duty cycling
 11. Fan speed/CFM control
 12. Heating/cooling interlock
 13. Hot water reset
 14. Chilled water reset
- D. DDC panels shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
1. It shall be possible to use any of the following in a custom process:
 - a. Any system measured point data or status
 - b. Any calculated data
 - c. Any results from other processes
 - d. User-defined constants
 - e. Arithmetic functions (+, -, *, /, square root, exp, etc.)
 - f. Boolean logic operators (and/or, exclusive or, etc.)
 - g. On-delay/off-delay/one-shot timers
 2. Custom processes may be triggered based on any combination of the following:
 - a. Time interval
 - b. Time of day
 - c. Date
 - d. Other processes
 - e. Time programming
 - f. Events (e.g., point alarms)
 3. The custom control programming feature shall be documented in English.
- E. Alarm management shall monitor and direct alarm information to operator devices. Each DDC panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to noncritical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the DDC panel's ability to report alarms be affected by operation of a PC workstation or local I/O device, or by communications among panels on the network.
1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
 2. The user shall be able to define the specific system response to alarm at each point. Alarms shall be prioritized. Each DDC panel shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
 3. Alarm reports and messages shall be directed to a user-defined list of operator devices.
 4. In addition to the point's descriptor and the time and date, the user shall be able to print, display, or store an alarm message to more fully describe the alarm condition or direct operator response.
 5. Operator-selected alarms shall initiate a call to a remote operator device.
- F. A variety of historical data collection utilities shall manually or automatically sample, store, and display system data for points as specified in the I/O summary.
1. DDC panels shall store and report point history data for selected analog and digital inputs and outputs. Methods of collection shall be either by a predefined time interval or upon a predefined change of value.

2. DDC panels shall provide high resolution sampling for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point I/O summary. Provide capability to view or print trend and tuning reports.
- G. DDC panels shall automatically accumulate and store run-time hours for digital input and output points as specified in the point I/O summary.
 - H. DDC panels shall automatically sample, calculate, and store consumption totals on a daily, weekly or monthly basis for user-selected analog and digital pulse input type points as specified in the point I/O summary.
 - I. DDC panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis for points as specified in the point I/O summary.
- 2.35 APPLICATION-SPECIFIC CONTROLLERS (ASC)
- A. Each DDC panel shall be able to extend its performance and capacity through the use of remote application-specific controllers (ASCs).
 - B. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.
 - C. Terminal equipment controllers:
 1. System shall control each piece of equipment through direct connection to a DDC or ASC. Terminal equipment shall include, but not be limited to, the following:
 - a. Unit conditioners (fan-coil units)
 2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. As a minimum, 50 percent of the point outputs (except for unit ventilator controllers) shall be of the universal type, either modulating or two-position. Terminal equipment controllers utilizing proprietary control signals and actuators shall not be acceptable. Provide DDC panels or ASCs with industry standard outputs for control of terminal equipment.
 3. Each controller shall perform its primary control function independent of other DDC panel LAN communication, or if LAN communication is interrupted. The controller shall receive its real-time data from the DDC panel time clock and shall ensure LAN continuity. Each controller shall include algorithms incorporating proportional, integral, and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via terminals as specified herein.
 4. Provide each terminal equipment controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in nonvolatile EEPROM, EPROM and PROM, or minimum of 72-hour battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Operating programs shall be field-selectable for specific applications. Specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of applications are not acceptable.
 5. Unit conditioner controllers shall support the following types of terminal units as a minimum:

a. Fan-coil units

(1) Fan-coil units may be of the following types:

- a) 2-pipe heating or cooling

2.41 PERSONAL COMPUTER OPERATOR WORKSTATION

- A. Provide personal computer operator workstations for command entry, information management, network alarm management, and database management functions. All real-time control functions shall be resident in the DDC panels.
1. Provide workstation(s) of equal capability located at Custodial Office.
 2. Workstation shall consist of a flat panel color monitor, personal computer with minimum 3 GB RAM, 160-GB hard drive and controller, mouse, 16 x DVD +/- RW, 56.0 Kb modem, and 101-key enhanced keyboard. Personal computer shall have a minimum 2.5 GHZ Intel Pentium Dual Core processor or equivalent by AMD, 10/100/1000 Network Interface with RJ-45 ethernet port.
 3. The display provided for system operation shall have a diagonal screen measurement of no less than 19 inches and a minimum display resolution of no less than 1440 x 900 pixels. Separate controls shall be provided for color, contrasts and brightness. The screen shall be nonreflective.
- B. Provide a laser printer with 600 by 600 dpi resolution at each workstation location for recording alarms, operator transactions, and systems reports.

2.42 PORTABLE OPERATOR'S TERMINAL (POT)

- A. Provide portable operator terminals with a minimum LCD display of 80 characters by 25 lines and a full-featured keyboard. The POT shall be handheld and plug directly into individual distributed control panels as described below. Provide a user-friendly, English-language-prompted interface, not codes requiring look-up charts.
- B. Functions of the POT connected at any DDC controller:
1. Access all DDC panels on the network.
 2. Backup and restore DDC controller data bases for all system panels, not just the DDC Controller connected to.
 3. Display all point, selected point and alarm point summaries.
 4. Display trending and totalization information.
 5. Add, modify, or delete any existing or new system point.
 6. Command, change setpoint, enable or disable any system point.
 7. Program and load custom control sequences as well as standard energy management programs.
- C. Functions of the portable operator's terminal connected to any application-specific controller:
1. Provide connection capability at either the ASC or a related room sensor to access controller information.
 2. Provide status, setup, and control reports.
 3. Modify, select, and store controller data base.
 4. Command, change setpoint, enable or disable any controller point.

2.43 OPERATOR WORKSTATION SOFTWARE

A. Basic interface description:

1. Operator workstation interface software shall use English-language prompting, English-language point identification, and industry standard PC application software. The software shall provide, as a minimum, the following functions.
 - a. Graphical viewing and control of environment.
 - b. Scheduling and override of building operations.
 - c. Collection and analysis of historical data.
 - d. Definition and construction of dynamic color graphic displays.
 - e. Editing, programming, storage, and downloading of controller databases.
2. Provide a graphical user interface which shall use a mouse or similar pointing device and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays with the pointing device.
 - a. Provide that all operations can also be performed using the keyboard as a backup interface device.
 - b. Provide at least 10 special function keys to perform often-used operations.
3. The software shall provide multi-tasking that allows the user to run several applications simultaneously. The mouse shall be used to quickly select and switch between multiple applications. This shall be accomplished through the use of Microsoft Windows or similar industry standard software that supports concurrent viewing and controlling of systems operations.
4. Multiple-level password access protection shall be provided to allow the user manager to limit workstation control, display, and data base manipulation capabilities.
5. Software shall allow the operator to perform commands including, but not limited to, the following:
 - a. Start up or shut down selected equipment
 - b. Adjust setpoints
 - c. Add/modify/delete time programming
 - d. Enable/disable process execution
 - e. Lock/unlock alarm reporting for points
 - f. Enable/disable totalization for points
 - g. Enable/disable trending for points
 - h. Override PID loop setpoints
 - i. Enter temporary override schedules
 - j. Define holiday schedules
 - k. Change time/date
 - l. Automatic daylight savings time adjustments
 - m. Enter/modify analog alarm limits
 - n. Enter/modify analog warning limits
 - o. View limits
 - p. Enable/disable demand limiting for each meter
 - q. Enable/disable duty cycle for each load
6. Reports shall be generated and directed to either CRT displays, printers, or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:
 - a. A general listing of all points in the network

- b. List of all points currently in alarm
- c. List of all points currently in override status
- d. List of all disabled points
- e. List of all points currently locked out
- f. DDC controller trend overflow warning
- g. List all weekly schedules
- h. List of holiday programming
- i. List of limits and deadbands

B. Scheduling:

1. Provide a graphical spreadsheet-type format for time-of-day scheduling and overrides of building operations. Provide the following spreadsheet graphic types as a minimum:
 - a. Weekly schedules
 - b. Zone schedules
 - c. Monthly calendars
2. Weekly schedules shall be provided for each building zone or piece of equipment with a specific occupancy schedule. Each schedule shall include columns for each day of the week as well as holiday and special day columns for alternate scheduling on user-defined days. Equipment scheduling shall be accomplished by simply inserting occupied and unoccupied times into appropriate information blocks on the graphic. In addition, temporary overrides and associated times may be inserted into blocks for modified operating schedules. After overrides have been executed, the original schedule will automatically be restored.
3. Provide zone schedule for each building zone. Each schedule shall include all commandable points residing within the zone. Each point may have a unique schedule of operation relative to the zone's occupancy schedule, allowing for sequential starting and control of equipment within the zone. Scheduling and rescheduling of points may be accomplished easily via the zone schedule graphic.
4. Monthly calendars for a 24-month period shall allow scheduling of holidays and special days in advance. Holidays and special days shall be user-selected with the pointing device and shall automatically reschedule equipment operation as previously defined on the weekly schedules.

C. Collection and analysis of historical data:

1. Trending capabilities shall allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or changes of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting.
2. Trend data report graphics shall allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of at least 6 points. Provide additional functionality to allow any trended data to be transferred easily to an off-the-shelf spreadsheet package. This shall allow the user to perform custom calculations such as energy use, equipment efficiency, and energy costs and shall allow for generation of these reports on high-quality plots, graphs, and charts.

D. Dynamic color graphic displays:

1. Color graphic floor plan displays and system schematics for each piece of mechanical equipment, including air-handling units, chilled water systems and hot water boiler systems, shall be provided as indicated in the point I/O summary to optimize system performance analysis and speed alarm recognition.

2. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or text-based commands.
 3. Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.
 4. The environment of the PC operator workstation shall allow the user to simultaneously view several graphics at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
 5. Graphic generation software shall allow the user to add, modify, or delete system graphic displays.
- E. System configuration and definition:
1. All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.
 2. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:
 - a. Add/delete/modify DDC panel
 - b. Add/delete/modify operator workstations
 - c. Add/delete/modify application-specific controllers
 - d. Add/delete/modify points of any type and all associated point parameters and tuning constants
 - e. Add/delete/modify alarm reporting definition for points
 - f. Add/delete/modify control loops
 - g. Add/delete/modify energy management applications
 - h. Add/delete/modify time and calendar-based programming
 - i. Add/delete/modify totalization for points
 - j. Add/delete/modify historical data trending for points
 - k. Add/delete/modify custom control processes
 - l. Add/delete/modify any and all graphic displays, symbols and cross-reference to point data
 - m. Add/delete/modify dial-up telecommunication definition
 - n. Add/delete/modify all operator passwords
 - o. Add/delete/modify alarm messages
- F. Additional workstation software:
1. Automatic communications shall include the following features as a minimum:
 - a. Manual communication from the workstation to remote networks shall be accomplishable using only a mouse to select and request the desired remote connection.
 - b. Alarms shall automatically communicate with the workstation for display at the terminal and for hard-copy printout at the associated event printer.
 - c. Alarms shall, at the operator's option, communicate with a stand-alone printer to provide for real-time alarm printouts even when the workstation is off-line (such as when it is being used to run operator-selected third party software).
 - d. Trend data shall be scheduled for automatic updating to the workstation at operator-selected times. The operator shall also have the option of manually collecting trend data at any time.

PART 3 - EXECUTION

3.20 HARDWARE AND SOFTWARE INSTALLATION

- A. Install the control system in accordance with manufacturer's instructions, complete and operating as shown and specified.
- B. See drawings for the level of controller required for each type system control.

3.61 TESTS

- A. Installer shall test, calibrate, and adjust the system and perform final field test. Engineer shall witness tests.
- B. Final field test:
 - 1. Sensors: Cross-check each sensor by comparing the reading at the sensor to a standard traceable to the National Institute of Standards and Technology (NIST).
 - 2. Control points: Cross-check each control point by comparing the control command to the field-controlled device.
 - 3. Verify that systems are operable from local controls in the specified failure mode upon panel failure or loss of power.
 - 4. Submit test results as required in "Submittals" in Part 1 above.
- C. Compliance inspection: Schedule compliance inspection only after installer has conducted all the test operations required above and successfully completed them, as substantiated by the required submittals. Conduct the compliance inspection with the Owner's designated representative and the Engineer. Conduct each activity described on the "Compliance Inspection Checklist" attached at the end of this Section. When each activity is satisfactorily completed, the Owner's representative (user) and the Engineer (A/E) will initial and date the line provided on the checklist.
 - 1. If any item on the checklist cannot be complied with, submit a written explanation.
 - 2. Complete the checklist and submit as required in "Submittals" in Part 1.

3.81 OPERATING INSTRUCTIONS

- A. Coordinate instruction period with requirements of Section 230500.
- B. Provide competent instructors to give full instruction to designated personnel in the adjustment, operation, and maintenance of the system installed, rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. Training shall be held during normal work hours of 8:00 a.m. to 4:30 p.m. weekdays as follows:
- C. Provide two 8-hour days of training for Owner's operating personnel. Training shall include:
 - 1. Explanation of drawings, operations, and maintenance manuals.
 - 2. Walk-through of the job to locate control components.
 - 3. Operator workstation and peripherals.
 - 4. DDC panel and ASC operation/function.
 - 5. Operator control functions including graphic generation and field panel programming.
 - 6. Operation of portable operator's terminal.
 - 7. Explanation of adjustment, calibration, and replacement procedures.

- D. Provide 4 hours of additional training quarterly for a period of one year from final completion of the project.
- E. The Owner may require personnel to have more comprehensive understanding of the hardware and software. Additional training shall be available from the installer, after completion of the work of the project. Provide description of available local and factory customer training.

END OF SECTION 230923

Compliance Inspection Checklist follows Section.

COMPLIANCE INSPECTION CHECKLIST

Project: _____

1. Manually generate an alarm at a remote DDC panel to demonstrate the capability of the workstation and alarm printer to receive alarms within 5 seconds.

User _____ Date _____ A/E _____ Date _____

2. Disconnect an operator workstation in the central control room and manually generate an alarm at a remote DDC panel to demonstrate the capability of the system printer to receive alarms when the workstation is disconnected from the system.

User _____ Date _____ A/E _____ Date _____

3. Disconnect one DDC panel from the network to demonstrate that a single device failure shall not disrupt or halt peer-to-peer communication. Panel to be disconnected shall be selected by the Engineer.

User _____ Date _____ A/E _____ Date _____

4. At a DDC panel of the Engineer's choice, display on the portable operator's terminal:
 - a. At least one temperature setpoint and at least one status condition, (for example, on or off for a system or piece of equipment attached to that panel), as well as for points at another DDC panel on the network.
 - b. The diagnostic results as specified for a system or piece of equipment attached to that panel as well as for a system or piece of equipment attached to another DDC panel.
 - c. The ability to add a new point to the DDC panel with the POT and have it automatically uploaded to the workstation to modify that panel's stored database.

User _____ Date _____ A/E _____ Date _____

5. At an ASC of the Engineer's choice, disconnect the LAN connection to demonstrate its lack of reliance on a DDC panel to maintain full control functionality.

User _____ Date _____ A/E _____ Date _____

END OF CHECKLIST

SECTION 231123 - NATURAL-GAS PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Piping, specialties, and accessories for natural-gas systems within building and to gas meters.

1.14 RELATED SECTIONS

- A. Pipe assembly: Section 230500.
- B. Trenching: Section 230501.
- C. Valve charts and tags: Section 230523.
- D. Pressure gages: Section 230519.
- F. Grounding: Section 260526.

1.15 UTILITY CONNECTION

- A. New gas service will be installed by Baltimore Gas and Electric Co. Make arrangements for, and have this service installed, at the appropriate scheduled time. Submit the bill upon completion of this part of the work. Owner will pay the utility company.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data:
 - 1. Pipe, valves, fittings and accessories.
 - 2. Dielectric fittings.
 - 3. Pressure regulators.
 - 4. Cabinet for emergency shutoff valve.
- C. Certifications:
 - 1. Test and approval of gas piping installation by the authorities having jurisdiction.

1.40 QUALITY ASSURANCE

- A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel."
- B. Pipe shall be certified by the manufacturer to meet referenced standards and shall bear a label, directly on the pipe, indicating compliance.
- C. UL label and local testing (if required): As specified in Section 230500, Common Work Results for HVAC.
- D. Pipe shall be certified by the manufacturer to meet referenced standards and shall bear a label, directly on the pipe, indicating compliance.

1.42 REGULATORY REQUIREMENTS

- A. Installation of gas piping shall meet requirements of the authority having jurisdiction, the gas supplier for gas service, and NFPA 54.
- B. Upon completion of the work, the piping shall be tested as required by inspection authorities having jurisdiction.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. 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.
- B. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.
- C. Protect stored PE pipes and valves from direct sunlight.

PART 2 - PRODUCTS

2.10 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A53, black steel, Schedule 40, Type E (electric resistance welded).
 - 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 metal gaskets.
 - e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
 - 5. Protective Coating for Underground Piping: Either high density polyethylene, or polypropylene copolymer, equal to products of General Steel Industries, Inc., nominal thickness 25 to 60 mils, adhered to pipe with modified rubber adhesive.
 - a. Heat-shrinkable pipe sleeves, semi-rigid polyethylene that shrink onto the joint when heated, equal to "Thermofit" manufactured by Raychem Corporation.
 - b. Field-applied primer and tape, equal to "Polyken No. 900-12" utility tape and "Polyken No. 1027" primer manufactured by Polyken Division of The Kendall Company.

2.15 PIPING SPECIALTIES

- A. Appliance Flexible Connectors: equal to BrassCraft ProCoat or Dormont.

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Corrugated stainless-steel tubing with polymer coating.
4. Operating-Pressure Rating: 0.5 psig (3.45 kPa).
5. End Fittings: Brass or zinc-coated steel.
6. Threaded Ends: Comply with ASME B1.20.1.
7. Maximum Length: 72 inches (1830 mm.)

- B. Cabinet: Equal to Potter-Roemer 1800 Series valve cabinet, 20 gage steel box with recessed, semi-recessed or surface-mounted cabinets. Door and frame: Stainless steel. Provide sign on glass, white 2-inch high letters on red background, which reads "EMERGENCY GAS SHUTOFF VALVE."

2.16 JOINING MATERIALS

- A. Joint Compound and Tape: Suitable for natural gas.
- B. Welding Filler Metals: Comply with AWS D10.12 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 (540 deg C) complying with AWS A5.8. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.20 MANUAL GAS SHUT-OFF VALVES

- A. NPS 2 (DN 50) and smaller: Two-piece, standard or full port, bronze ball valves with bronze trim: MSS SP-110.
1. Acceptable manufacturers: Subject to compliance with requirements, provide valves by one of the following manufacturers:
 - a. Apollo Valves
 - b. Milwaukee Valve Co.
 - c. Nibco
 - d. Stockham Valve & Fittings
 - e. Walworth Co.
 - f. Watts Regulator
 2. Body: Bronze, complying with ASTM B584.
 3. Ball: Chrome-plated bronze.
 4. Stem: Bronze; blowout proof.
 5. Seats: Reinforced TFE; blowout proof.
 6. Packing: Threaded-body packnut design with adjustable-stem packing.
 7. Ends: Threaded.
 8. CWP Rating: 600 psig (4140 kPa).
 9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 10. Service: Suitable for natural and LP gas service with "WOG" indicated on valve body.
- B. NPS 2.5 (DN 65) through NPS 6 (DN150): Non-lubricated eccentric plug valves, MSS SP-78, UL Listed.
1. Equal to SMG Key Port series 400 fig. 425.
 2. Body: Cast iron.

3. Plug: cast iron.
4. Stem Seal: Compatible with natural and LP gas.
5. Plug Seal: Resilient Nitrile-Butadiene (NBR)
6. Ends: flanged
7. Operator: Square head or lug type with lever handle.
8. Pressure rating: 175 psig (1208 kPa) WOG
9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural and LP gas service with "WOG" indicated on valve body.

C. NPS 2.5 (DN 65) through NPS 10 (DN 250): Cast iron ball valve, MSS SP-72

1. Equal to American Valve, Inc. Model 4000.
2. Body: Epoxy-coated cast iron, ASTM A126, Class B
3. Ball: cast iron / PFA (Teflon) fused or stainless steel.
4. Stem: Stainless steel, blow-out proof
5. Stem seal: PTFE.
6. Seats and body seals: PTFE.
7. Plug Seal: Resilient Nitrile-Butadiene (NBR)
8. Ends: flanged
9. Operator: Lever handle.
10. Pressure rating: 200 psig (1380 kPa) WOG
11. Service: Suitable for natural and LP gas service with "WOG" indicated on valve body.

2.30 PRESSURE REGULATORS

A. General:

1. Provide products by Fisher Controls or equal by Eclipse, Sensus, Maxitrol, or American Meter Company.
2. Provide capacities at inlet pressures and discharge pressures indicated on the drawings.

B. 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. Atmospheric vent: Threaded vent pipe connection.

C. 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. Atmospheric vent: Threaded vent pipe connection.

PART 3 – EXECUTION

3.01 GENERAL

- A. Install piping as indicated on the drawings, in accordance with the regulations of the local authority and local gas utility company, and in accordance with installation and testing requirements of Section 230500.
- B. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

3.10 OUTDOOR PIPING INSTALLATION

- A. Install underground, natural-gas piping buried at least 36 inches (900 mm) below finished grade. Comply with requirements in Section 230501 "Excavation and Fill for HVAC Work" for trenching and backfill requirements.
- B. 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.
- C. Install fittings for changes in direction and branch connections.
- D. Install pressure gage downstream from each service regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

3.11 INDOOR PIPING INSTALLATION

- A. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- B. Conceal pipe in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
 1. In Floors: Install piping under floor slab on earth in conduit, as specified in Section 230500, Common Work Results for HVAC.
 2. In Floor Channels: Install gas piping in floor slab in trench duct specified in Section 230500, Common Work Results for HVAC.
 3. 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.
 4. Prohibited Locations:
 - a. Do not install natural-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 natural-gas piping in solid walls or partitions.

- 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 otherwise indicated.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping free of sags and bends.
- F. Take branches from horizontal runs from side or top of such runs. A tee shall be placed at the bottoms of risers in gas piping. Bottom of tee shall be provided with a six-inch-long nipple and cap the same size as riser. When riser is concealed, the cap shall project through wall to be accessible and shall be properly marked with engraved plastic nameplate, "DANGER, GAS, CLEANOUT". Red background with white letters.
- G. Verify final equipment locations for roughing-in.
- H. Install fittings for changes in direction and branch connections.
 - 1. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- I. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- J. Install valves and specialties readily accessible for operation and maintenance, with ample clearance for turning wheel handles or operators.
 - 1. Valves are not permitted in accessible ceiling space whether or not used as air plenums.
 - 2. Install valves in branch lines as indicated on drawings.
- K. Drips and Sediment Traps: Install natural-gas piping at uniform grade down toward drip and sediment traps Install drips at points where condensate may collect, including service-meter outlets.
 - 1. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - 2. 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 6 inches (150 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- L. Vents:
 - 1. Provide vent lines to the outside in accordance with the regulations of the local authority and local gas company. Vents are required on main gas regulators, pilot regulators, high- and low-pressure switches, diaphragm gas valves, and dump valves.
 - 2. Install vents separately to the outside unless otherwise permitted by the local authority or gas company. Vents shall terminate in a screened, turned-down elbow.
 - 3. Vents shall not terminate below any window, door, air intake, or opening to the building. Dump-valve vent shall terminate at the highest possible point outside to prevent nuisance gas leak complaints.
- M. Install pressure gage downstream from each line regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

N. Install sleeves, seals and plates for piping penetrations of building structure, walls, ceilings, and floors. Comply with requirements in Section 230502 "Sleeves and Plates for HVAC Piping."

O. Electrical:

1. Install a grounded jumper conductor attached to both ends of each stainless-steel flexible connector. Refer to Section 260526, Grounding and Bonding, for installation requirements.

3.15 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. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

3.16 CONNECTIONS

A. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

1. Do not use natural-gas piping as a grounding electrode.

B. Install piping adjacent to appliances to allow service and maintenance of appliances.

C. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches (1800 mm) of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

- D. Install a valve at house side of each gas meter.

3.70 LABELING AND IDENTIFYING

- A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.
- B. Install detectable warning tape directly above gas piping, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.80 PAINTING

- A. Comply with requirements in Section 230500 "Common Work Results for HVAC" for painting interior and exterior natural-gas piping.
- B. Paint exposed, exterior metal piping, valves, service regulators, service meters and piping specialties.

END OF SECTION 231123

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Heating water supply and return.
- B. Chilled water supply and return.
- C. Chilled/heating water supply and return.

1.13 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Control valves: Section 230908.
- B. Wells: Sections 230519 and 230913.
- C. Pressure switches: Section 230913.
- D. Flow switches: Section 230913.

1.14 RELATED SECTIONS

- A. Piping materials, installation, and testing: Section 230500.
- B. Trenching: Section 230501.
- C. Pipe cleaning and water treatment: Section 232500.

1.20 REFERENCES

- A. American Society of Testing and Materials
 - 1. ASTM A 53: Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded
 - 2. ASTM B 88: Standard Specification for Seamless Copper Water Tube
 - 3. ASTM A 536: Standard Specification for Ductile Iron Casting
 - 4. ASTM F1476 – Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications
- B. American Society of Mechanical Engineers
 - 1. ASME B 16.1: Cast Iron Pipe Flanges and Flanged Fittings
 - 2. ASME B 16.4: Gray-Iron Threaded Fittings
 - 3. ASME B 15.5: Pipe Flanges and Flanged Fittings, NPS 1/2 to NPS 24
 - 4. ASME B 16.9: Factory-Made Wrought Steel Butt Welding Fittings
 - 5. ASME B 16.18: Cast Copper Alloy Solder Joint Pressure Fittings
 - 6. ASME B 16.22: Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: Each specified material and product.

1.40 QUALITY ASSURANCE

- A. The pipe manufacturer shall certify piping to meet referenced standards and shall bear a label, directly on the pipe, indicating compliance.
- B. All grooved couplings and fittings shall be the products of a single manufacturer. Grooving tools shall be approved by grooved component manufacturer.
- C. Date stamp all castings used for coupling housings for quality assurance and traceability.

PART 2 - PRODUCTS

2.10 PIPE

- A. Black steel, threaded or plain end: ASTM A 53, Grade B, Type E (electric resistance welded), Schedule 40.
- B. Black steel, grooved: ASTM A 53, Grade B, Type E (electric resistance welded); NPS 3 (DN 80) and smaller, rolled grooved; NPS 4 (DN 100) and larger, cut or rolled grooved.
- C. Copper tubing ASTM B 88, Type L hard drawn, plain end or roll grooved.

2.20 FITTINGS

- A. For steel piping: Cast iron, Class 125, ASME B16.1 (flanged) and 16.4 (threaded).
 - 1. NPS 2 (DN 50) and smaller, threaded.
 - 2. NPS 2.5 (DN 65) and larger, flanged.
- B. Fittings and couplings for grooved steel pipe:
 - 1. Couplings, gaskets and fittings capable of withstanding 300 psig (2070 kPa) working pressure at 230 deg F (110 deg C)
 - 2. Grooved-end fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 53/A 53M, Type F, E, or S, Grade B factory-fabricated steel with grooved ends or shoulders constructed to accept grooved-end couplings of same manufacturer. Elbows NPS 4 (100 mm) and larger shall be long radius type.
 - 3. Rigid type couplings: Two ductile or malleable iron housing segments and EPDM or nitrile gasket of central cavity pressure-responsive design and of grade to suite intended service; with nuts, and bolts to secure grooved pipe and fittings.
 - a. NPS 2.5 (DN 65) through NPS 12 (DN 300): Equal to Victaulic Style 07 or 107.
 - 4. Mechanical flange adapters for grooved steel pipe.
 - a. NPS 2.5 (DN 65) through NPS 24 (DN 600): Ductile iron castings, flat face, Class 125 and 150 bolt-hole pattern, equal to Victaulic Style 741 / W741; Class 300 bolt-hole pattern, equal to Victaulic Style 743 / W743.
- C. Fittings for plain end copper pipe: Solder joint, cast brass, ASME B16.18; or wrought copper, ASME B16.22.

- D. Welding fittings: Steel, 150 psi (1030 kPa), ASME B16.9, products of Bonney Forge, Hackney Ladish, Inc., Penn Machine, The Phoenix Forge Group, Taylor Forge, or Weldbend Corporation.
- E. Companion flanges: ANSI B16.5, Class 150, welding neck or slip-on type.
- F. Dielectric pipe nipples shall comply with Section 230508.
- G. Threaded joints for heating and cooling water systems: Compound recommended by manufacturer for use at the temperature and pressure of the system, or "Teflon" pipe thread tape, specified in Section 230500, Common Work Results for HVAC.
- H. Elbows in piping NPS 4 (DN 100) and larger shall be long radius type.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Install piping as indicated on the drawings and in accordance with provisions of Section 230500 and the piping installation schedule at the end of the Section.
- B. Install automatic control valves, pressure and flow switches and insertion wells furnished under Automatic Temperature Controls sections, as indicated on the drawings, and in accordance with manufacturer's instructions.
- C. Provide dielectric nipples between steel and copper pipe.
- D. Boiler trim piping connections to pump controllers, low water cutoffs and water columns shall be assembled with red brass pipe and crosses instead of tees and elbows. Plug the unused openings of crosses with red brass plugs to serve as cleanouts. Run valve blowdown from each water chamber to discharge into drain. Controllers shall be piped in parallel.

3.60 FIELD QUALITY CONTROL

- A. Install grooved joints in accordance with the manufacturer's latest published installation instructions. Grooved ends shall be clean and free from indentations, projections, and roll marks. Gaskets shall be molded and produced by the coupling manufacturer, and shall be verified as suitable for the intended service.
- B. A factory-trained field representative (direct employee) of the mechanical joint manufacturer shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. The factory-trained representative shall periodically review the product installation and ensure best practices are being followed. Contractor shall remove and replace any improperly installed products. A distributor's representative is not considered qualified to conduct the training.

3.75 CLEANING AND TREATMENT

- A. Clean piping and provide water treatment as specified in Section 232500, HVAC Water Treatment.

3.90 SCHEDULES

HEATING AND COOLING PIPE INSTALLATION SCHEDULE				
Contractor has option where more than one x appears on a line				
	A	B	C	D
Heating water	X	X	X	X
Chilled water	X	X	X	X
Condenser water	X	X	X	X

- A. Schedule 40 black steel, welded; NPS 2.5 (DN 65) and larger pipe sizes with welded or flanged fittings.
- B. Schedule 40 black steel, rolled groove; NPS 2.5 and 3 (DN 65 and 80) pipe sizes with mechanical coupling and fittings.
- C. Schedule 40 black steel, cut or rolled groove; NPS 4 (DN 100) and larger pipe sizes with mechanical couplings and fittings.
- D. Copper tubing; NPS 2 (DN 50) and smaller pipe sizes with cast or wrought fittings.

END OF SECTION 232113

SECTION 232115 - PREFABRICATED INSULATED PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Insulated piping for underground installation, factory-designed and completely prefabricated.
- B. Systems:
 - 1. Chilled water supply and return

1.14 RELATED SECTIONS

- A. General information and piping materials and methods: Section 230500.
- B. Underground warning tape: Section 230501.
- C. Piping: Section 232113.
- D. Trenching: Section 230501.

1.25 SYSTEM DESCRIPTION

- A. Install system with copper pipe for chilled water supply and return.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Shop drawings: Provide shop drawings at a scale no smaller than 0.25 inch equals 1 foot (1:50), showing layout of piping system and identifying pipe segments and fittings.
- C. Product data:
 - 1. Each type of piping system, with fittings and accessories; include manufacturer's written installation instructions.
 - 2. Insulation.
 - 3. Jacket.
- D. Certificates:
 - 1. Qualifications of manufacturer's factory-trained technician.
 - 2. Supervising technician's certificate that system has been installed in accordance with manufacturer's recommendations.

1.40 QUALITY ASSURANCE

- A. System shall be installed under the supervision of the manufacturer's qualified factory-trained technician.
- B. Pipe shall be certified by the manufacturer to meet referenced standards and shall bear a label, directly on the pipe, indicating compliance.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Store fitting insulation materials at temperatures between 50 and 70 degrees F (28 and 39 degrees C) until the time of installation.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide system manufactured by Perma-Pipe, or comparable system by one of the following:
 - 1. Insul-Tek
 - 2. Perma-Pipe
 - 3. Rovanco Corp.
 - 4. Thermacor
 - 5. Thermal Pipe Systems
 - 6. Tricon Piping Systems, Inc.

2.10 MATERIALS

- A. General: Steel pipe and fitting materials shall comply with requirements of Sections 230500 and 232113.
- B. Steel pipe and fittings: Schedule 40 black steel pipe, ASTM A53 Type B, with welding fittings, 150 psi ANSI B16.9
- C. Insulation: Rigid polyurethane, no less than 90 percent closed cell.
 - 1. Density: 1.9 to 2.1 lbs per cubic foot.
 - 2. k Factor: 0.14.
 - 3. Thickness: Nominal 1.5 to 1 inch, manufacturer's standard to meet published tables of heat transfer data.
- D. Jacket: ASTM D 1784, PVC, Type I, Grade 1, 0.06 inches thick.

2.20 PREFABRICATED SYSTEM WITH COPPER CARRIER PIPE

- A. Factory-designed and completely prefabricated system, including insulated, jacketed pipe and fittings, and accessories.
- B. Insulation ends shall be protected with factory-applied moisture barrier.
- C. Factory-provided fittings and accessories shall be provided factory-insulated and -jacketed, and sealed for shipment and handling.
- D. Manufacturer's standard compatible sealing materials.

PART 3 - EXECUTION

3.05 PREPARATION

- A. Piping adjoining the preinsulated piping shall be anchored at or near the point of connection.

3.20 INSTALLATION

- A. Install preinsulated piping under the supervision of the manufacturer's qualified representative, in accordance with manufacturer's recommendations.
- B. Where insulated lengths are cut, seal.
- C. Install in trench as indicated on the drawings, on a bed of sand, giving uniform support along entire length.
- D. Connect piping by butt welding as specified in Section 230500, Common Work Results for HVAC.
- E. Immediately after piping is installed in the trench, partially backfill in the middle of each unit, leaving joints exposed for testing.
- F. Hydrostatically test piping as required in Section 230500, Common Work Results for HVAC.
- G. After tests are successfully completed with no leaks, insulate connections and fittings as required, and hand place and hand tamp backfill in 4-inch layers to at least 12 inches above the top of the insulation. Complete backfilling as specified in Section 230501. Do not use tracked or wheeled vehicles for compacting.
- H. Submit certificate of manufacturer's representative as required in the article "Submittals" above.

END OF SECTION 232115

SECTION 232123 - HVAC PUMPS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Base-mounted pumps.
- B. In-line circulators.

1.14 RELATED SECTIONS

- A. Motor: Section 230513.
- B. Power factor correction: Section 230513.
- C. Vibration-control supports: Section 230548.
- D. Variable frequency drives: Section 262923.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: Base-mounted pumps and in-line circulators.
 - 1. Include description of all options and accessories.
- C. Include data verifying compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
- D. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, including plans, and sections, showing any changes in the wiring, arrangement, or access necessary to accommodate the unit furnished.
- E. Shop drawings shall show complete dimensions of complete assembled unit with accessories.
- F. Include wiring diagram showing factory and field wiring.

1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 230500, Common Work Results for HVAC.
- B. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide the scheduled product, or comparable product by one of the following:

B. Base-mounted end-suction pumps

1. Armstrong Pump Co.
2. Aurora Pumps
3. ITT Bell and Gossett
4. Paco Pumps; Grundfos Group
5. Patterson Pump Co.
6. Taco Inc.

C. In-line pumps

1. Armstrong Pump Co.
2. Aurora Pumps
3. ITT Bell and Gossett
4. Paco Pumps; Grundfos Group
5. Patterson Pump Co.
6. Taco Inc.

2.30 BASE-MOUNTED PUMPS, GENERAL

- A. Pump shall have capacities and current characteristics as shown on the drawings.
- B. Pumps shall be factory-assembled and -tested. Casings shall allow removal and replacement of impellers without disconnecting piping.
- C. Motors: Comply with requirements of Section 230513.
1. Motors with 120-V, single-phase current shall have built-in overload protection, and shall be permanent split-capacitor type.
 2. Motors 10 hp (7.5 kW) and larger not controlled by variable frequency drives shall be power factor corrected as specified in Section 230513.
- D. Seals: Internally flushed (self-flushing) type:
1. On open circuits such as cooling towers, use mechanical seals with cyclone sediment separator assembly. On closed circuits such as heating water, use mechanical seals.
 2. Mechanical seals shall consist of carbon steel rotating ring, stainless steel spring, ceramic seat, and flexible bellows and gasket rated for 250 degrees F (120 degrees C).
 3. Cyclone sediment separator assembly shall consist of copper tubing seal flush lines, Kynar Cyclone sediment separator, sight flow indicator, and bronze stop cocks, installed as recommended by the pump manufacturer.
- E. Couplings: Flexible, capable of absorbing torsional vibration and shaft misalignment, complete with metal coupling guard. For pumps operating with variable-frequency drives, provide couplings suitable for variable-speed duty.
- F. Mounting frame: Factory-welded frame and cross members, fabricated of steel channels and angles conforming to ASTM B 36. Fabricate for mounting pump casing, coupler guard, and motor. Grind welds smooth prior to application of factory finish. Mounting holes for field-installed motors shall be field-drilled.
- G. Motor: Secure to mounting frame with adjustable alignment.

2.31 BASE-MOUNTED END-SUCTION PUMPS

- A. Taco FI Series, or Bell and Gossett 1510. Comply with general requirements for base-mounted pumps above.
- B. General description: Pumps shall be base-mounted, centrifugal, separately-coupled, end-suction, single-stage, bronze-fitted, vertical (radially) split-case design, and rated for 175 psig (1200 kPa) working pressure and 250 degrees F (120 degrees C) continuous water temperature.
- C. Casing: Cast iron, with flanged piping connections, and threaded gage tappings at inlet and outlet flange connections.
- D. Impeller: Statically and dynamically balanced, closed, single-suction, fabricated from cast bronze conforming to ASTM B 584, keyed to shaft and secured by a locking cap screw. Trim impeller for pumps not controlled by variable frequency drives to match specified performance. Impeller for pumps controlled by variable frequency drives shall be full size.
- E. Shaft and sleeve: Steel shaft, with bronze sleeve.
- F. Bearings: Ball.
- G. Provide suction diffuser with adjustable support foot, inlet connection to suit pipe size, outlet to suit pump suction size, angle-type body with inlet vanes, and stainless steel combination diffuser/strainer with 3/16-inch (4.8-mm) diameter openings. The flow direction shall be from inside to outside. Include disposable fine mesh bronze strainer.

2.33 IN-LINE CIRCULATOR PUMPS

- A. Taco Inc. Series 1600 or Series 100, Bell and Gossett Series 60, or Armstrong Series 1000. Each pump shall have capacity and current characteristics shown on the drawings.
- B. General: Horizontal in-line, centrifugal, separately-coupled, single-stage, radially split-case design, with mechanical seals and resiliently mounted motor.
 - 1. Seals: Rated for 250 degrees F (120 degrees C) operating temperature.
- C. Casing: Cast iron, bronze fitted, with flanged piping connections conforming to ASME B16.1; operating pressure 175 psig (1200 kPa) maximum.
- D. Impeller: Statically and dynamically balanced, closed, overhung, single-suction, fabricated from cast bronze, and keyed to shaft.
- E. Shaft and sleeve: Steel shaft and cupro-nickel sleeve. Provide flinger (slinger) on shaft between motor and seals to prevent liquid that leaks past pump seals from entering motor bearings.
- F. Bearings: Replaceable bearing cartridge, oil-lubricated, steel and cupro-nickel journal and thrust type.
- G. Couplings: Flexible, capable of absorbing torsional vibration and shaft misalignment.

2.35 DRIVE PROTECTION

- A. Pumps shall be provided with guard over belt drive or flexible couplings as required by OSHA and MOSHA.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Base-mounted pumps:
 - 1. On slab on grade, anchor to concrete equipment foundation.
 - 2. Set preliminary pump alignment and grout pump base.
 - 3. When grout is set and hardened, make final pump alignment.
- B. Provide in-line pumps with motor in correct position. Provide necessary bracket to building structure to support the pump independently from the piping.
- C. Heating and cooling pumps shall have balancing valves with a memory stop in discharge piping for setting proper flow and head.
- D. Provide check valves in discharge lines with non-slam spring-loaded type.
- E. Provide valves for isolating pump on both suction and discharge sides of each pump.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 230500, provide operating instructions.
- B. Provide at least one hour of additional instruction time for the equipment specified in this section.

END OF SECTION 232123

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Refrigerant piping and accessories for equipment in related sections.

1.14 RELATED SECTIONS

- A. Piping materials and methods: Section 230500.
- B. Air-cooled condensing units: Section 236313.
- C. Split-system air conditioning units: Section 238127.
- D. Fan-coil units: Section 238219.
- E. Variable refrigerant system: Section 238128.
- F. Hangers and supports: Section 230529.

1.26 DESIGN REQUIREMENTS

- A. Refrigerant piping shall be sized by the manufacturer of the refrigeration compressor, as specified in sections describing refrigeration equipment.
- B. Design pressures: Calculated in accordance with "System Design Pressure" in ASHRAE 15.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data:
 - 1. Piping, fittings, solder, flux, and pipe joint compound.
 - 2. Each type of valve, including materials, classifications, arrangement, dimensions and required clearances, and installation instructions.
 - 3. Each type of device and accessory.
- C. Shop drawings:
 - 1. Precharged tubing, including sizes and approximate lengths of lines.
 - 2. Built-up system piping diagram, including sizes, details, and accessories.
 - 3. Submit system design pressures for use in testing system. In accordance with the International Mechanical Code, "Field Test" for refrigeration systems, include the pressures listed on the condensing unit, compressor, or compressor unit nameplate, and the settings of pressure relief devices.
- D. Certifications: Provide certificate of field tests in a form acceptable to the authority having jurisdiction, as part of the permit and inspection records. Certificate shall include no less than:
 - 1. Name of refrigerant.
 - 2. Field test pressure applied to high and low sides of the system.

3. Signature and printed name of the installer.

1.40 QUALITY ASSURANCE

- A. Pipe shall be certified by the manufacturer to meet referenced standards and shall bear a label, directly on the pipe, indicating compliance.

PART 2 - PRODUCTS

2.10 MATERIAL

- A. Refrigerant: HFC 410a.

2.11 PIPING (PRECHARGED TUBING SYSTEM)

- A. Refrigerant pipe: Precharged Type L soft drawn, preinsulated seamless copper tubing, ASTM B 280.

2.12 PIPE AND FITTINGS (BUILT-UP SYSTEMS)

- A. Refrigerant pipe: ASTM B 280 Type ACR hard-drawn seamless copper tubing.
- B. Fittings: Wrought copper, solder-joint type, ANSI B16.22. Flare fittings shall conform to SAE J513d.

2.13 ACCESSORIES (BUILT-UP SYSTEMS)

- A. System: Provide the listed accessories as a minimum on each built-up system, in accordance with approved shop drawings. Items provided by the equipment manufacturer with the equipment are acceptable.
- B. Brazing solder: Minimum 15 percent silver content.
- C. Flux: Non-corrosive.
- D. Stop valve: Refrigerant type globe valve, either packless or with sealed cap, UL listed. Connections: threaded, flared, or soldered. Valves meeting this specification are manufactured by the Henry Valve Company.
- E. Charging valves: Packless globe-valve type, balanced action, solder outlet with male flare inlet, equal to Henry Type 623.
- F. Expansion valves: Refrigerant type equal to products of Alco, Mueller, or Sporlan.
- G. Solenoid valves: Rising-stem type.
- H. Flexible connectors: Equal to Anaconda Series FY with a working pressure rating of 450 psi.(3,103 kPa), high tensile braid covering, and female ends compatible with copper tubing.
- I. Sight glass: Equal to Sporlan "See-All" moisture indicating Type SA-ODF solder.
- J. Filter-drier: Equal to Sporlan "Catch-All," with replaceable core of highly efficient desiccant that will not powder or pack.

- K. Make threaded joints with pipe joint compound approved for the service, or "PTFE" tape.

PART 3 - EXECUTION

3.20 INSTALLATION (PRECHARGED TUBING)

- A. Install piping as shown on drawings and in accordance with manufacturer's instructions and approved shop drawings.

3.21 INSTALLATION (BUILT-UP SYSTEM)

- A. Drawings indicate routing of refrigerant piping. Install in accordance with approved shop drawings.
- B. Install piping with all joints flared or brazed.
- C. Install flexible connectors at condensing unit and at air-handling unit, unless flexibility is otherwise properly built into piping system.
- D. Purge oil-pumped dry nitrogen through refrigerant piping while brazing to prevent scale forming inside the tubing. (To permit flow and to avoid pressure build-up, always make sure the other end of the line is open.)
- E. Vent relief valves to the atmosphere in accordance with ASHRAE 15 and 34.
- F. Provide system with charging valve, expansion device, moisture-indicating sight glass, filter-drier with three-valve bypass, and solenoid valve.

3.61 LEAK TEST

- A. After the refrigeration systems have been installed, perform a leak test before evacuating the systems.
 - 1. The cylinder of oil-pumped nitrogen shall be equipped with a shutoff valve, pressure reducing valve, cylinder pressure gage, line pressure gage, and bleed valve.
- B. Remove controls or relief valves which could be damaged by test pressures.
- C. Separate the high side from the low side and bleed in enough refrigerant to raise the system pressure to 12 to 15 psig (83 to 103 kPa). Then, using oil-pumped dry nitrogen, raise the pressures to the test pressures established as required in "Submittals" in Part 1 above.
- D. With the test pressures in the system, tap each connection sharply with a rubber or rawhide mallet.
- E. Test the entire system for leaks.
- F. Bleed off the pressure into cylinders, in accordance with ASHRAE Guideline 3, and repair leaks. Do not attempt to repair a leak while the system is under pressure. Do not repair bad joints by remelting and adding more brazing material. Take joint apart, thoroughly clean, and remake as a new joint.
- G. Retest the system if a leak is found.

- H. When tests and repairs are complete, replace valves or controls removed for protection.
- I. Submit test certificate required in "Submittals" in Part 1 above.

3.64 EVACUATION

- A. To evacuate the system, use a vacuum pump capable of producing at least 1 mm (0.039 inches) mercury absolute vacuum. Proceed as follows:
 1. Connect an accurate high vacuum gage (Micron), such as a Stoke's or Zimmerli gage, to the system. Do not use compound gages.
 2. Connect the vacuum pump to both the high and low sides of the system. Leave the compressor suction and discharge valves closed. Evacuate the system to 2.5 mm (0.098 inches) mercury absolute. Keep ambient air temperatures above 60 degrees F (15.6 degrees C) during the evacuation process.
 3. Break the system vacuum with oil-pumped dry nitrogen. Open the compressor suction and discharge service valves and re-evacuate the system to 2.5 mm (0.098 inches) mercury absolute.
 4. After the system has been double evacuated to 2.5 mm (0.098 inches) mercury absolute, close the vacuum-pump suction valve and stop the pump. Allow the system to stand under a vacuum a minimum of 12 hours and recheck the vacuum. Notify the Architect in time for him to verify the test pressure at beginning and end of time limit, before proceeding to charge the system.

3.65 CHARGING

- A. Charge the system with refrigerant through the liquid-line charging valve. Use a clean strainer-drier in the charging line, along with a pressure gage and shut-off valve to control pressures. Before starting the compressor, ascertain that the oil sight glass, if provided, is 75 percent full, and suction and discharge valves back-seated.

3.66 FINAL START-UP PROCEDURE

- A. Check out operating and safety controls in accordance with the compressor manufacturer's recommendations.
- B. Recheck the oil level in the sight glass at frequent intervals. It should not drop below 50 percent level.
- C. Adjust compressor suction unloaders, if provided, for proper evaporator-compressor balance to maintain the scheduled minimum discharge temperature.
- D. Reinspect the system after it has been in normal operation for at least 72 hours. At this time, instruct the Owner in the operation and maintenance of the equipment, as required in the equipment section.

3.71 LUBRICATION

- A. If it becomes necessary to add oil to the system, use only the oil recommended by the compressor manufacturer.

END OF SECTION 232300

SECTION 232500 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Clean heating and cooling piping systems:
 - 1. Chilled/heating water.
- B. Closed heating and cooling systems: Test water and provide chemical treatment.
- C. Provide supplies and maintenance for 2 years after the date of Substantial Completion.

1.14 RELATED SECTIONS

- A. Chemical feeder for closed systems: Section 230508.
- B. Cleaning and disinfecting domestic water system: Section 221116.
- C. Heating and cooling piping: Section 232113.

1.27 PERFORMANCE REQUIREMENTS

- A. There shall be no chromates, polyphosphates, or heavy metals in the chemical formulation.
- B. Water treatment shall not in any way affect the life of any part of the water cooling or heating equipment, pipe, valves, fittings, and other appurtenances.
- C. Water treatment system shall introduce chemicals into each system only when the system is operating.
- D. Chilled/heating water systems shall maintain these conditions:
 - pH.....8 to 10.5
 - Corrosion inhibitor.....00 to 150 ppm as molybdate or 1000 to 1500 ppm sodium nitrite

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Shop drawings:
 - 1. Chemicals proposed for each treated system, with calculations showing that treatment will produce the levels required in "Performance Requirements" above.
 - 2. System diagram and wiring diagram of treatment equipment.
- C. Product data:
 - 1. Chemicals and concentrations proposed for system cleaning.
 - 2. Manufacturer's installation instructions.
 - 3. Each item of equipment.
- D. Certifications:

1. Names and qualifications of staff proposed to be assigned to the project.
2. List of at least five projects meeting the requirements described in the article "Quality Assurance" below, each with name, address, and telephone number of contact person who can confirm satisfactory installation and operation of the system.

E. Water analysis.

F. Test reports required below for service visits. Submit one copy of each report directly to the Owner, and one to the Architect.

1.40 QUALITY ASSURANCE

A. UL label and local testing (if required): As specified in Section 230500, Common Work Results for HVAC.

B. Water treatment subcontractor shall supervise the cleaning of the piping systems and submit a certificate of compliance with the specification.

1.41 QUALIFICATIONS OF WATER TREATMENT SUBCONTRACTOR

A. Contractor shall engage and the Architect shall approve an independent water treatment subcontractor, who shall provide the water treatments specified in this section.

B. Is located in the Baltimore/Washington, DC, metropolitan area.

C. Is regularly engaged in providing and servicing systems of similar type and capacity to that installed on this project.

D. Has a record of at least five projects similar to this project in type and size, which have been in place and operating satisfactorily for at least 5 years.

E. Offers 24-hour emergency service.

F. Maintains locally an adequate stock of parts and supplies to service this system and equipment.

G. Have service contracts available.

1.60 PROJECT CONDITIONS

A. Obtain water analysis from the local agency supplying water to the site, or by a test.

B. The chilled water system will not be operational when the weather is cool.

1.91 MAINTENANCE SERVICE

A. For 2 years after Substantial Completion, test and maintain systems with monthly service calls. Provide chemicals and labor necessary to maintain each system's conditions as specified in "Performance Requirements."

B. Perform an analysis at the time of each visit, or within 72 hours at the firm's laboratory, and submit report as required in "Submittals."

- C. Closed systems: During the final 30 days of the project 2-year service period, water treatment supplier's representative shall test each closed system.
 - 1. Make minor adjustments if required to correct chemical balance.
 - 2. If system conditions indicate significant leaks, notify Contractor. After piping corrections or repairs, adjust system chemical balance.

PART 2 - PRODUCTS

2.01 ACCEPTABLE SUPPLIERS AND MANUFACTURERS

- A. Water treatment system subcontractors:
 - 1. ARC Water Treatment Company, Inc.
 - 2. Ecolab (Water Management)
 - 3. Olin Water Services
 - 4. U.S. Water
- B. Specified equipment is based on recommendations of ARC Water Treatment. Equivalent equipment recommended by other named acceptable suppliers may be substituted, subject to approval.

2.10 MATERIALS

- A. For cleaning heating- and cooling-piping systems: Detergent, dispersant, and other required chemicals, in accordance with approved product data.
- B. For each system's chemical treatment: Chemicals in accordance with approved product data, to maintain the conditions specified in "Performance Requirements" above.

PART 3 - EXECUTION

3.05 CLEANING PIPING SYSTEMS

- A. Before flushing and cleaning the system, isolate coils by closing valves to heating and cooling equipment, and open bypass valves.
- B. Flushing portions of the system:
 - 1. After a piping loop has been completed and prior to the installation of strainer baskets, flush that portion of the system. Connections shall be same size as piping being flushed, or one size smaller.
 - 2. When a major section of the building has been completed, repeat the same procedure, except that pipe connections shall be limited to NPS 1.5 (DN 40).
 - 3. Flushing shall remove sediment, scale, rust and other foreign substances.
 - 4. After flushing, install strainers and pressure-test system and repair leaks.
- C. Flushing building system: After various portions of the piping system have been tested and flushed and system is substantially completed, fill the system completely with water, venting all trapped air, and operating the pump.
 - 1. Open a drain at the system low point while replacing the water at the same rate.
 - 2. Continue flushing until clean water shows at the drain, but for not less than two hours.
 - 3. After flushing, remove strainers and clean and replace them.

- D. Chemical cleaning: Fill system with sufficient detergent and dispersant to remove dirt, oil, and grease.
 - 1. Circulate for at least 48 hours.
 - 2. Open a drain valve at the lowest point and bleed while the system continues to circulate. Assure that the automatic makeup valve is operating.
 - 3. Continue until water runs clear and all chemicals are removed. Sample and test the water until pH is the same as pH of makeup water.
 - 4. After chemical cleaning, remove strainers and clean and reinstall them.
- E. After flushing and cleaning the system, open valves to coils of heating and cooling equipment and close bypass valves.
- F. Submit certificate and test results.

3.22 INSTALLING CHEMICAL TREATMENT FOR CLOSED SYSTEM

- A. Perform water analysis and submit recommended chemicals for treatment.
- B. Using the chemical feeder specified in Section 230508, HVAC Piping Specialties, install chemicals.
- C. At the end of the project correction period, test the closed system and correct concentration of chemicals if required. Submit test and adjustment report.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 230500, provide operating instructions.
- B. Treatment representative shall start up equipment and instruct Owner's representative on its operation.

END OF SECTION 232500

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. HVAC supply, return, and exhaust metal ductwork and plenums in pressure classes from minus 2 to plus 10 inches wg (minus 500 to plus 2490 Pa).
- B. Single-wall round duct.
- C. Double-wall round and rectangular duct.
- D. Insulated flexible ducts in HVAC systems.
- E. Special ductwork for kitchen hood.
- F. Sealants.
- G. Duct leakage testing.
- H. Acoustical lining.

1.14 RELATED WORK SPECIFIED ELSEWHERE

- A. Firestopping: Section 230507.
- B. Flashing ducts through roof: Section 230506.
- C. Insulation: Section 230713.
- D. Louvers and vents: Section 233714.
- E. Balancing: Section 230593.

1.20 REFERENCES

- A. SMACNA HVAC DCS: SMACNA HVAC Duct Construction Standards, Metal and Flexible.
- B. SMACNA RIDCS: SMACNA Round Industrial Duct Construction Standards.
- C. SMACNA: HVAC Air Duct Leakage Test Manual.
- D. ASHRAE Handbook: Fundamentals.
- E. ASTM C 423: Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
- F. ASTM C 1071: Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Material).
- G. ASTM D 1330: Rubber Sheet Gaskets.
- H. ASTM G 21: Determining Resistance of Synthetic Polymeric Materials to Fungi.

- I. ASTM G 22: Determining Resistance of Synthetic Polymeric Materials to Bacteria.
- J. ACGIH-01: American Conference of Governmental Industrial Hygienists, Industrial Ventilation: A Manual of Recommended Practice.
- K. UL 181: Factory-Made Air Ducts and Air Connectors.

1.21 DEFINITIONS

- A. Seam: Joining of two longitudinal (parallel to the direction of airflow) edges of duct surface material. All other duct surface connections are joints.
- B. Joints: Transverse joints (perpendicular to the direction of airflow); branch and subbranch intersections; duct collar tap-ins; louver and air terminal connections to ducts; access door and access panel frames and jambs; duct, plenum, and casing abutments to building structures.

1.27 SYSTEM PERFORMANCE REQUIREMENTS

- A. The duct system design, as indicated, has been used to select and size air moving and distribution equipment and other components of the air system. Do not change the layout or configuration of the duct system except as specifically approved in writing. Accompany requests for modifications with calculations showing that the proposed design will provide the original design results without increasing the system total pressure.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Shop drawings:
 - 1. Schedule of duct systems with applicable pressure classes and leakage classes.
 - 2. Fabrication, assembly, and installation for each duct system: Indicate duct dimensions, sheet metal thickness, reinforcement spacing, and seam and joint construction; and components and attachments to other work.
 - 3. Calculations when required as specified in the article "System Performance Requirements" above.
 - 4. Schedule of sealing methods for each type of seam and joint.
- C. Product data:
 - 1. Acoustical duct lining, adhesives, and sealants.
 - 2. Hangers and supports.
 - 3. Manufactured ducts and fittings.
 - 4. Joint and sealing materials.
 - 5. Manufacturer's installation instructions.
- D. Test reports: Air Duct Leakage Test Summary: Submit data on forms as indicated in the SMACNA HVAC Duct Leakage Test Manual. (See sample form at end of section.)

1.40 QUALITY ASSURANCE

- A. Specified and scheduled duct construction exceeds SMACNA requirements. Comply with specifications and schedules, and for materials or methods not specified or scheduled, comply with SMACNA HVAC DCS and RIDCS.

- B. Comply with NFPA 90A and 90B.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design products: Subject to compliance with requirements, provide specified or noted products, or comparable product by one of the following:

- 1. Manufactured ducts and fittings:

- a. Eastern Sheet Metal
- b. Hamlin Sheet Metal
- c. LaPine Metal Products
- d. Lindab, Inc.
- e. McGill Airflow Corp.
- f. MKT Metal Manufacturing
- g. Semco Mfg. Inc.
- h. SPIRAmir

- 2. Manufactured joint connectors:

- a. Ductmate Industries
- b. C.L. Ward & Family Inc.

- B. Special use ducts and fittings: Scheduled manufacturers and named products are intended to set a standard for materials, quality of construction, and performance.

2.10 MATERIALS

- A. Galvanized steel sheets: Lock-forming quality, ASTM A 653/A 653M, coating designation G90 (Z275).

- B. Stainless steel sheets: ASTM A 480/A 480M, Type 304.

- 1. Ducts exposed to view: No. 4 finish on exposed surface.
- 2. Concealed ducts: No. 2B finish.

- C. Reinforcement shapes and plates: Galvanized steel where installed on galvanized sheet steel ducts; carbon steel on carbon steel ducts and compatible materials on aluminum and stainless steel ducts.

- D. Tie rods: Galvanized steel, minimum diameter 0.25 inch (6 mm) for ducts up to 36 inches (900 mm); 0.375 inch over 36 inches (900 mm).

- E. Vapor barrier: Polyethylene sheet, 6 mils (0.15 mm) thick, conforming to Federal Specification UU-P-147 for permeability.

2.11 JOINT AND SEALING MATERIALS

- A. Flexible joint material for connections to vibrating equipment: Specified in Section 233300, Duct Accessories.

- B. Duct joint and seam sealants: UL classified, fire-resistive, conforming to NFPA 90A and 90B, high pressure type (up to 10 inches (2490 Pa) SMACNA pressure class) equal to the following products:
1. Indoor application: Hardcast "Iron Grip" (IG-601) brush-on water-based vinyl acrylic sealing mastic.
 2. Outdoor application:
 - a. Hardcast "Versa-Grip" (VG-102) brush-on indoor/outdoor water-based polyester/synthetic resin sealant with UV inhibitors.
 - b. Hardcast "Aluma-Grip" (AFT-701) pressure sensitive sealant on a roll. Two-mil (0.05-mm) aluminum foil backing, peel-off release liner, 33-mil (0.8-mm) modified elastomeric butyl sealant (100 percent solids). To be used outdoors only.
 3. Flange gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.12 CLOSED-CELL ACOUSTICAL LINING FOR RECTANGULAR DUCT WORK

- A. Fiber-free, closed cell, flexible foam acoustical insulation, ASTM C 1534; meeting requirements of NFPA 90A and 90B at specified thickness. Equal to K-Flex Duct Liner Gray or equal product by Armacell.
- B. Density: Nominal 2 lbs per cu ft (32 kg per cu m).
- C. Vapor transmission without jacketing: Less than 0.06 per inch.
- D. Thermal performance: 0.25 k-value at 75 degree F.
- E. Resistance to microbial growth: Tested and shown to support no growth of the following:
1. Fungi in accordance with ASTM G 21.
 2. Bacteria in accordance with ASTM G 22.
- F. Thickness:
1. Typical: One inch (25 mm) thick, ASTM C 423 (Type A mounting) noise reduction coefficient (NRC) at least 0.50.
 2. Where indicated: Two inches (51 mm) thick, ASTM C 423 (Type A mounting) NRC at least 0.85.
- G. Adhesive for acoustical lining: LEED compliant, non-flammable elastomer contact adhesive designed for attaching closed cell insulation to sheet metal.

2.20 ROUND DUCTS AND FITTINGS

- A. Single-wall, spiral round duct and fittings: Equal to McGill Airflow "Uni-Seal" spiral duct with "Uniform" fabricated fittings.
1. Material(s): Galvanized steel.
 2. Fittings for branch connections shall be conical type. Centerline radius of elbows shall be 1.5 times the diameter. Duct access door shall be equal to type AR-W.
 3. Metal thickness:

<u>Round Ducts</u>	<u>Steel Gage</u>
Up to 14 inches diameter	26
15 through 26 inch diameter	24
27 through 36 inch diameter	22
37 through 50 inch diameter	20
51 through 60 inch diameter	18
61 inches and over	16 welded joints
Fittings up to 36 inch diameter	20
Fittings 37 to 50 inch diameter	18
Fittings 51 inches and over	16

- B. Single-wall, longitudinal-seam round duct and fittings: Fabricate of galvanized steel according to SMACNA HVAC DCS.
 - 1. Seam: Flat lock; snap-lock seam not permitted.
- C. Double-wall, insulated, spiral round duct and fittings: Equal to McGill Airflow Corporation "Acousti-K27." Dimensions indicated are the outside dimension of outer wall.
 - 1. Walls: galvanized steel, inner duct perforated.
 - 2. Construction: Spiral lock seam.
 - 3. Insulation: Fiberglass, coated to prevent particles from penetrating the fiberglass, resistance to microbial growth of fungi in accordance with ASTM G 21 and bacteria in accordance with ASTM G 22, maximum 1.5 pounds per cubic foot density, 1 inch thick.

2.21 RECTANGULAR DOUBLE-WALL DUCTS

- A. Equal to McGill Airflow "Rectangular-k27" with an outer shell, an inner liner, and insulation between.
- B. Thermal conductivity: 0.26 at 75 degrees F (0.037 at 24 degrees C) mean temperature.
- C. Outer shell: Galvanized steel, 22 gage, Pittsburgh lock construction, with "TDC" end connectors.
- D. Insulation: Fiberglass, coated to prevent particles from penetrating the fiberglass, resistance to microbial growth of fungi in accordance with ASTM G 21 and bacteria in accordance with ASTM G 22, maximum 1.5 pounds per cubic foot density, 1 inch thick.
- E. Inner liner: Perforated galvanized steel sheet, 22 gage, Pittsburgh lock construction.
- F. End connections: Manufactured joint connectors.

2.22 MANUFACTURED SPECIAL FLEXIBLE DUCTS AND FITTINGS

- A. Insulated flexible duct for HVAC systems: Factory pre-insulated, complying with NFPA 90A, listed as Class 1 air duct in conformance with UL 181, and UL rated for a positive pressure of 10 inches of water (2490 Pa) (through 18-inch (457-mm) size).
 - 1. Core: Non-metallic airtight polyester with galvanized wire helix.
 - 2. Insulation: Fiberglass blanket, 1.5 inches (38 mm) thick, 0.75 lb density, and k factor 0.28 at 75 degrees F (23.9 degrees C).

- a. Vapor barrier: Aluminized and reinforced.
 - 3. Connections: Accessories required by manufacturer's published instructions.
- 2.24 HANGERS AND SUPPORTS
- A. Hangers: Galvanized sheet steel, or round, galvanized steel, threaded rod.
 - 1. Hangers installed in corrosive atmospheres: Electro-galvanized, all-thread rod; or hot-dipped-galvanized rods with threads painted with zinc-rich paint after installation.
 - 2. Straps and rod sizes: Conform to SMACNA HVAC DCS for sheet steel width and gage and steel rod diameters.
 - B. Duct attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- 2.80 FABRICATION
- A. Dimensions indicated on drawings are outer dimensions of ducts. Dimensions indicated for double-wall ducts are outer dimensions of outer wall.
 - B. Verify field measurements and resolve conflicts, before beginning to fabricate ductwork, as specified in Part 3 below.
- 2.81 DUCT CONSTRUCTION
- A. Construct ductwork using the Duct Construction Schedule on the drawings. Schedule includes duct system pressure class requirements, minimum sheet metal gages, leakage allowances, and maximum reinforcement spacing. These requirements exceed the requirements of SMACNA HVAC DCS.
 - B. Construct ductwork of galvanized steel, except where another material is noted on drawings or specified.
 - C. Construct gravity duct systems (nonfan-powered), such as pressure relief and transfer, in accordance with SMACNA HVAC DCS minimum one inch pressure class unless otherwise scheduled.
 - D. Crossbreak or bead ducts of dimensions of 12 inches (305 mm) and over in pressure classes under 2 inches (500 Pa).
 - E. Plenums, casings, and access doors: Construct in accordance with SMACNA HVAC DCS.
 - 1. Casings and plenums for negative pressures greater than 3 inches wg (747 Pa): Construct in accordance with SMACNA RIDCS.
 - 2. Where casings and plenums are on the suction side of fans, and negative pressure which exceeds their construction class may occur, provide safety relief panels or dampers as indicated on drawings.
 - F. Joint connections shall be constructed in accordance with SMACNA HVAC DCS, or with a manufactured duct connection system equal to Ductmate Industries "Ductmate," selected to assure compliance with leakage factors indicated on the drawings. Snap-lock or flat-lock seams are not acceptable.

- G. Engineered duct systems using metal gages or reinforcing less than required in the schedules on the drawings are not acceptable.
- H. Where not otherwise specified, scheduled, or detailed, construct ductwork in accordance with SMACNA HVAC DCS.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Before fabricating ductwork, make field measurements and coordinate layout of ductwork shown on the drawings with building components and work of other trades. Resolve conflicts and obtain written approval for deviations before fabrication.
- B. Provide duct systems complete with built-in accessories as specified herein, in other sections of the specifications, as indicated on the drawings, and, where not otherwise indicated, in accordance with SMACNA HVAC DCS.
- C. Thoroughly clean duct and duct fittings before they are installed, and keep them clean until the acceptance of the completed work. Use a duct cap cover on all unfinished ends to prevent moisture, dirt particles, dust, and debris from entering the installed ductwork during construction.

3.21 INSTALLING METAL DUCTWORK

- A. Provide ductwork shown on drawings and specified herein.
- B. Ductwork shall not penetrate rated partitions where fire or smoke dampers are indicated on the drawings. Connect ductwork only after the damper installation is complete and accepted, as specified in Section 233300, Duct Accessories.
- C. Connecting duct to louver: Provide angles or damper collars as required. Slope duct down toward louver. Blank off any part of louver not required to be open, with double pan panels constructed of the same material as the connecting duct, 1.5 inches (38 mm) thick and insulated with 1.5 inches (38 mm) of fiberglass insulation. Seal connection.
- D. Install metal ductwork neat in appearance. Interior surfaces shall be smooth and free of obstructions. Duct lines shall be true and smooth. Where ducts pass through openings in partitions, ceilings and floors, fit them with trim angles to close joint between duct and construction.
- E. Acoustical lining: Where indicated on drawings, or required by specifications, install acoustic lining on interior surfaces of ducts. Sizes shown on the drawings for rectangular ducts are sheet metal dimensions and include allowance for liner thickness. Install in accordance with SMACNA HVAC DCS, except as the following requirements are more stringent.
 - 1. Adhesive: Adhere liner to interior surfaces of duct with 100 percent coverage. Before assembling lined sections, coat exposed abutting edges of liner with adhesive.
 - 2. Mechanical fasteners: On 16-inch (406-mm) maximum centers on top and sides; on 4-inch (100-mm) centers within 2 inches (50 mm) of leading edge of transverse joints on top, bottom, and sides.
- F. Support ductwork on metal straps or rods in accordance with SMACNA HVAC DCS and as specified. Comply with manufacturers' load ratings and application data for each type of support and fastener.

1. Connections to substrate:
 - a. Bar joists: Suspend from top chord or panel points.
 - b. Concrete: Inserts or fasteners specified in Section, Hangers, Supports, and Anchors. Install inserts before placing concrete.
 - c. Structural steel: Beam clamps.
 - d. Do not support ductwork from gypsum roof deck supports or metal deck.
 2. Ducts 54 inches (1372 mm) wide and under: Strap hangers shall extend down sides of ducts and attach to underside with at least two sheet metal screws per strap. Straps shall be made of the same metal as the ducts they are attached to.
 3. Ducts over 54 inches (1372 mm) wide: Support on trapeze hangers formed of structural angle irons and hanger rods in accordance with SMACNA HVAC DCS.
 4. Round ducts: Support on rods or galvanized straps, and bands, as shown in SMACNA HVAC DCS and in accordance with manufacturer's recommendations.
 5. Support horizontal ducts within 2 feet (610 mm) of each elbow and within 4 feet (1220 mm) of each intersection, in addition to spacing required by SMACNA.
 6. Support vertical ducts at a maximum interval of 16 feet (4.9 m) and at each floor.
- G. Except in systems with minimum velocity standards, contractor has the option to eliminate reducing transitions and extend ductwork full size, providing space is available and conflict with work of other trades does not occur.
- H. Make bends and turns in ductwork using offsets and curved or square elbows as indicated on the drawings. Provide full radius elbows (centerline radius equals 1.5 times duct width). Provide turning vanes in square elbows, as specified in Section 233300, Duct Accessories. Make 90-degree branch duct connections using 45-degree entry fittings where indicated.
- I. Provide for and install in ductwork all automatic control systems dampers, thermometers, coils, sound attenuators, duct accessories and similar equipment furnished under this or other sections of the specifications. Where ATC dampers with frames and other accessories are mounted in ductwork, the ducts shall connect to the accessory frame in manner to provide 100 percent free area for air passage. Seal duct connections to frames with gaskets or duct sealant. Secure connections with pop rivets or sheet metal screws spaced no more than 3 inches (75 mm) on centers around both sides of entire frame. Provide angle iron or channel frames as required for mounting ATC dampers and manual dampers over weatherproof louvers for air intakes and exhaust.
- J. Generally, it is intended that all horizontal ductwork be a minimum of 10 inches (255 mm) above suspended ceiling (where applicable) to allow for removal of ceiling panels and ceiling-mounted light fixtures and devices.
- K. Large ductwork in mechanical equipment rooms, such as outdoor air, return air, and exhaust air duct connections to fans, air handling units, plenums, and appurtenances, shall be sufficiently braced with angle irons to prevent vibration and duct damage, and to reduce noise level.
- L. Assemble round ducts and fittings using duct sealant and sheet metal screws as recommended by the manufacturer.
- M. Flashing of ducts through outside walls shall be as detailed on the drawings.
- N. Where noted on the drawings provide sheet metal drain troughs under piping.

3.22 INSTALLING ROUND DUCT

- A. Single-wall: Single-wall, spiral duct and fittings.
 - 1. Exception: Single-wall, longitudinal-seam duct is permitted where concealed, in systems of 2 inches wg pressure class or less, for connections to individual air outlets.
- B. Double-wall: Where double-wall duct is indicated, provide double-wall, insulated spiral duct and fittings.

3.23 SEALING DUCTWORK

- A. Ducts shall be sealed so that they meet leakage factors scheduled on the drawings.
- B. Prior to sealing, ductwork shall be clean and dry, free of oil or grease.
- C. Apply sealant in accordance with the manufacturer's recommendations.
- D. Product application:
 - 1. Galvanized steel: Brush-on or pressure sensitive sealant, as applicable.
- E. Allow time for sealant to dry or cure, in accordance with manufacturer's recommendations, before leak testing.

3.24 INSTALLING INSULATED FLEXIBLE DUCT (HVAC SYSTEMS)

- A. Provide insulated flexible duct where shown on drawings. Install fully extended and route as directly as possible to supply outlets. Lengths shall not exceed 10 feet.
- B. Lay out bends and turns with the longest practicable radius, as a minimum exceeding SMACNA standards for radius of rigid duct radius elbows. Ends shall extend straight for at least 6 inches before beginning of bend.
- C. Connections: Coat at least 3 inches inside the end of the flexible duct core with duct sealant, install over the rigid duct, and secure with a duct clamp. After replacing the insulation and vapor barrier, secure with another duct clamp.
- D. Support flexible duct in accordance with the manufacturer's recommendations or SMACNA DCS, whichever is more stringent.

3.25 INSTALLING KITCHEN CANOPY EXHAUST DUCTWORK (NON-GREASE APPLICATIONS)

- A. Kitchen canopy exhaust ducts shall be fabricated of stainless-steel, all welded construction, and seams ground smooth (where exposed).
- B. Kitchen canopy exhaust duct shall extend to top of roof curb.

3.59 IDENTIFICATION

- A. Mark ductwork in accordance with requirements for identification specified in Section 230500, Common Work Results for HVAC.

3.61 AIR DUCT LEAKAGE TESTS

- A. Leakage test procedures shall be in accordance with SMACNA Leakage Test Manual.
- B. After installation and prior to insulating, test the ductwork for air leakage. Ducts to be tested, test pressures, and leakage factors (maximum volume of leakage per 100 sq ft (9.3 sq m) of duct surface area) shall be as scheduled on the drawings.
- C. Conduct tests before any equipment is connected that would be subject to damage from the test pressure. Provide temporary blank-offs or caps.
- D. Notify parties whose presence is necessary for the test; and in all cases, the Architect and testing and balancing subcontractor at least two normal work days prior to the actual test.
- E. While system is under test pressure, survey joints for audible leaks. Mark leakage points, shut down blower, and make repairs. Retest after duct sealant has dried or cured.
- F. If test duct sections exceed the allotted leakage levels, locate sources of leakage, make repairs and repeat test procedures until acceptable leakage levels are demonstrated.
- G. During the installation, continuously examine ductwork to ascertain that it is sealed properly.

3.75 CLEANING DUCT SURFACES

- A. Where ducts will be exposed and therefore are required to be painted, remove labels used for construction and clean surfaces ready for painting.

END OF SECTION 233113
Leakage test form follows Section

PROJECT NAME _____ PROJECT NO. _____

PAGE _____ OF _____

AIR DUCT LEAKAGE TEST SUMMARY

AIR SYSTEM _____

FAN CFM (Q) _____

LEAKAGE CLASS (G_L) _____

SPECIFIED TEST PRESSURE (P_t) _____

DUCT CONSTRUCTION PRESSURE CLASS (P_c) _____

DESIGN DATA				FIELD TEST DATA RECORD							
SUBJECT DUCT	SURFACE AREA IN FT ²	ALLOWABLE LEAKAGE		DIAMETER		PRESSURE "W.G.		DATE	PERFORMED BY	WITNESSED BY	ACTUAL CFM
			CFM (TEST SECTION)								
TOTAL SYSTEM				****	***	**	*****	****	****	****	
TEST SECTION(S)											

SECTION 233300 - DUCT ACCESSORIES

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Products and devices installed in ducts.
- B. Flexible joint fabric.
- C. Bird and insect screens.
- D. Volume extractors.
- E. Instrument test holes.
- F. Air turning vanes.
- G. Spin-in or dovetail fittings.
- H. Duct access doors.
- I. Sound attenuators.
- J. Dampers.
- K. Fire and smoke dampers.
- L. Duct clamps.

1.14 RELATED SECTIONS

- A. Access doors: Section 230503.
- B. Louvers and Vents: Section 233714.
- C. Duct-mounted smoke detectors: Section 283100.
- D. Diffusers, registers, and grilles: Section 233713.
- E. Damper actuators: Automatic temperature control sections.

1.20 REFERENCES

- A. AMCA 210: Laboratory Methods of Testing Fans for Rating.
- B. ASTM E 477: Test for Measurement of Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.
- C. ASTM E 2016: Standard Specification for Industrial Woven Wire Cloth.
- D. NFPA 90A: Installation of Air Conditioning and Ventilating System.
- E. NFPA 90B: Installation of Warm Air Heating and Air-Conditioning Systems.

- F. SMACNA-05: Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems.
- G. SMACNA HVAC DCS: HVAC Duct Construction Standards, Metal and Flexible.
- H. UL 555: Fire Dampers.
- I. UL 555S: Smoke Dampers.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: Each type of duct accessory included in the project.
 - 1. Include manufacturer's written installation instructions for each type of fire damper.
- C. Shop drawings: Detail equipment assemblies and indicate dimensions, loadings, required clearances, method of field assembly, components, locations, and size of each field connection. Detail these accessories:
 - 1. Special fittings and manual and automatic volume damper installations.
 - 2. Fire and smoke damper installations, including sleeves and duct access doors and panels.
- D. Certifications: Certified test data for dynamic insertion loss; sound power levels; airflow performance data, and static-pressure loss.

1.40 QUALITY ASSURANCE

- A. Work of this section shall comply with NFPA 90A and 90B, and SMACNA HVAC DCS.

1.92 EXTRA MATERIALS

- A. Provide one spare link for every four fire dampers installed in the project, with a minimum of two of each type.
- B. Deliver and store spare links in the cabinet for spare automatic sprinklers, or as directed by the Owner.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Manufacturers' names and specific products are described in the articles below to set a standard for materials, quality of construction, options and details, and performance. Provide named products, or equal products by other named manufacturers.

2.10 MATERIALS

- A. Sheet metal: As specified in Section 233113.
- B. Flexible joint fabric: Woven glass fabric with coating, complying with NFPA 701 for fire retardance and NFPA 90A for use in duct systems.

1. For use indoors: Equal to Ventfabrics "Ventglas," coated with polychloroprene (DuPont "Neoprene"), 30 ounces per square yard (850 g per 0.8 square meter).
 2. For use outdoors: Equal to Ventfabrics "Ventlon," coated with DuPont weather-, sunlight- and ozone-resistant "Hypalon," 26 ounces per square yard (732 g per 0.8 square meter).
- C. Bird screen: ASTM E 2016, general industrial-use wire cloth, Grade C, medium light or heavier, nominal 0.5-inch (13-mm) mesh and 0.063-inch (1.6-mm) wire diameter, aluminum or stainless steel.
1. Frame: Removable, rewirable, of same material and finish as the duct or accessory to which it is installed.
- D. Insect screen: ASTM E 2016, general industrial-use wire cloth, Grade C, medium light or heavier, T304 stainless steel, nominal 0.044-inch (1.12-mm) openings, 14 by 18 per inch (per 2.54 cm) mesh, 0.011-inch (0.28-mm) wire diameter, 67-percent open area.
1. Frame and fasteners: Removable, same material and finish as louver or accessory to which it is installed, and capable of screen replacements.

2.20 MANUFACTURED UNITS

- A. Volume extractors: Equal to Hart & Cooley "Vectrol" Type AVL R, with the equal to Young Regulator Co. No. 429 FD end bearing and No. 443-B 3/8-inch operator; or Type VLK, with worm-driven mechanism accessible through face of diffuser or grille with an 18-inch-long removable key operator.
- B. Instrument test holes for ductwork balancing stations: Equal to Ventfabrics "Ventlock" No. 699 or 699-2 as required for insulation thickness, with gasket for base, and threaded cap.
- C. Air turning vanes: Double vane type, constructed in accordance with SMACNA HVAC DCS, from the same material as the duct.
- D. Spin-in or dovetail fittings in accordance with SMACNA HVAC DCS are acceptable for a round take-off connection from a rectangular duct, provided they meet the duct pressure classification.

2.21 DUCT ACCESS DOORS

- A. SMACNA standard construction, Air Balance, Inc., Model FSA-100-H or equal by Ruskin, Inc., Airstream Products Company, Inc., or Commercial Acoustics. Access doors to fire protection devices shall comply with NFPA 90A.
- B. Construction: Door and frame fabricated of 24 gage galvanized steel, minimum size 16 inches (406 mm) by 16 inches (406 mm), or 16 inches (406 mm) by maximum duct size.
- C. Door: Hinged with continuous piano hinge; number of cam latches to suit door size. Insulated doors shall be double pan construction, one inch (25 mm) thick with one inch (25 mm) thick minimum 3.5 pound (56 kg per cubic meter) density fiberglass insulation cut full to require forcing into the pan.
- D. Gaskets: Continuous around perimeter, sealing frame to duct and door to frame, neoprene or foam rubber.
- E. As an option, provide round access doors equal to Ventfabrics "Ventlok Twist-In" doors, complete with safety holding cable, 12 inches (305 mm) diameter.

2.22 SOUND ATTENUATORS

- A. Manufactured by Dynasonic Systems, Inc., Semco, Ruskin Sound Control, Vibro-Acoustics, Commercial Acoustics Division of Metal Form Manufacturing, Aerosonics, or Price; sizes and types shown and scheduled on the drawings. Field fabrication will not be permitted.
- B. Materials: The entire attenuator shall be incombustible, moisture-resistant, and odorless.
 - 1. Outer casings: 22 gage galvanized steel, seams lock-formed.
 - 2. Interior baffles: 24 gage perforated galvanized steel.
 - 3. Acoustical filler material: Fiberglass, packed under compression to 4.5 pound density.
- C. Units for duct mounting: Outer casing seams mastic-filled; casings leakproof to a pressure differential of 8 inches wg (2000 Pa). Measure static pressure loss in accordance with ANSI/AMCA 210.
- D. Acoustical performance for duct-mounted units: Only tests made at an independent testing laboratory will be considered, and the test data must include acoustical performance and generated noise levels at various airflow velocities. Acoustical and pressure drop performance shall be as scheduled on the drawings.
 - 1. Insertion loss: Measured by the "Duct to Reverberation Room" method with airflow.
 - 2. Generated noise: Measured in accordance with ASHRAE 36B Test Method.
- E. Acoustical performance for transfer air units between spaces: Test by the procedure described in ASTM E 477, latest edition. Only tests made at an independent testing laboratory will be considered. Acoustical and pressure drop performance shall be as scheduled on the drawings.
- F. The same test sample shall have been used for both acoustic and aerodynamic measurement.

2.25 DAMPERS

- A. Where aluminum duct is required by the specifications, dampers shall be all aluminum construction.
- B. Manual volume dampers:
 - 1. 13 inches (330 mm) and larger in height: Balanced multi-louver, opposed-blade type with maximum blade width of 6 inches (155 mm), equal to Ruskin Model MD 35 with corrosion resistant, molded synthetic sleeve type bearing and 0.375-inch (9.5-mm) square control shaft; and with Young Regulator Co. Model No. 443B-3/8 damper regulators designed with 2-inch high base for mounting on externally insulated duct.
 - 2. 12 inches (305 mm) or less in height: Fabricated from 16 gage metal with hemmed edges, 0.375-inch (9.5-mm) square rod, Young Regulator Co. Model No. 443B-3/8 regulator designed with 2-inch high base for mounting on externally insulated duct and Model No. 429 FD end bearing.
- C. Pressure relief or static pressure-control counterbalanced backdraft dampers: Equal to Ruskin Type CBS-4 fabricated with steel channel frame with 0.3125-inch (7.9-mm) mounting holes. Blades shall be 14 gage aluminum with polyurethane foam seals on edges, maximum width 10 inches, mounted on a steel shaft with "oilite" bearings. Individual blades shall be adjustable for final setting in the field. Frame shall have a rust-inhibitive coating applied at the factory.

- D. Counterbalanced backdraft dampers for use in fan discharge: Equal to Ruskin Type CBS-7 fabricated with galvanized steel channel frame with 0.3125-inch (7.9-mm) mounting holes. Blades shall be 16 gage galvanized steel, maximum width 10 inches (255 mm), mounted on a steel shaft with ball bearings. Individual blades shall be connected together to work in unison. Frame shall have a rust-inhibitive coating applied at the factory.

2.27 FIRE DAMPERS

- A. Fire dampers shall comply with NFPA 90A and applicable building and fire code requirements. Fire dampers shall be equal to the models specified below, and UL 555 labeled for use in static systems.
- B. Dampers connected to ducts: Size and configuration suitable to the connected duct.
- C. Material, blades and frame: Galvanized sheet steel, no less than 0.064 inch (1.62 mm) thick.
- D. Blades: Folding, with 100-percent interlocking joints to form a continuous steel curtain when closed.
 - 1. Joints: 180 degrees of free movement.
 - 2. Operator: Constant-force, stainless-steel spring for horizontal applications.
- E. Fusible links: Replaceable, 165 degrees F (74 degrees C) rated.
- F. Sleeves: Galvanized sheet steel no less than 0.052 inch (1.3 mm) thick; length to suit wall or floor application; sleeves, angles, and methods of fastening meeting requirements of manufacturer's UL-approved installation instructions.
- G. Ratings and frame types: Equal to Air Balance Inc. 119 Series for use in 1-1/2-hour rated assemblies and 319 Series for use in 3-hour rated assemblies.
 - 1. Dampers in rated partitions between nonducted transfer grilles, or dampers terminating at a ducted wall grille or register: Type A frame, installed within or behind grille or register, access by removal of grille or register.
 - 2. Dampers connected to supply air ductwork: 100 percent free opening, Type C frame with welded-seam housing.
 - 3. Dampers connected to return air or exhaust air ducts: 90 percent free opening, Type B frame with welded-seam housing.

2.28 FIRE/SMOKE AND SMOKE DAMPERS

- A. Equal to Ruskin Model FSD-60, low-leakage type.
- B. Ratings:
 - 1. Combination Fire and Smoke Dampers:
 - a. Fire resistance in accordance with UL 555 no less than 1.5 hours.
 - b. Leakage in accordance with UL Standard 555S no higher than Leakage Class I (4 cfm per square foot at one inch wg).
 - c. Rated for use in static systems.
 - 2. Smoke Dampers: Same as combination dampers, except need not be rated for fire resistance.

- C. Double-skin airfoil-shaped blades, with a pressure loss of not more than 0.1 inch wg in full-open position at damper-face velocity of 2000 fpm (based on 36-inch by 36-inch damper).
- D. Sleeve: Furnish each damper complete with factory sleeve of length and gage required for satisfactory installation.
- E. Operator: Elevated temperature category B (250 degrees F (121 degrees C)) damper operator, electric or pneumatic as required by control system, factory-installed on exterior of sleeve and properly linked to damper operating shaft.
 - 1. Type: Spring-return fail-closed that will close damper upon power or pressure interruption.
 - 2. Ratings: Listed and labeled in accordance with UL 555 or 555S as fire or smoke damper operators as required by rating of damper.
 - 3. Coordinate damper operator sizing and voltage requirements with manufacturer.

2.70 ACCESSORIES

- A. Duct clamps for flexible duct and flexible fabric connections: Positive locking drawbands able to conform to any shape. Fabricate from a single piece of galvanized steel, with zinc-plated steel screw and buckle. Equal to "59 Series" manufactured by Ideal Division, Parker Hannifin Corporation.
- B. Nonmetallic duct clamps for flexible duct and flexible fabric connections: Heavy-duty adjustable type equal to products of Tyton Corporation, for 12-inch (305-mm) diameter and smaller flexible ductwork, complying with UL 181.
- C. 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 length to suit duct insulation thickness.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Duct accessories shall be mounted or installed properly in accordance with the manufacturer's instructions and as indicated on the drawings.

3.21 INSTALLING CONNECTIONS AND SCREENS

- A. Flexible connections: Install where duct connects to motor-driven equipment, and in other locations shown on drawings. Securely clamp flexible connection to duct and collar with duct clamps, providing 1 inch (25 mm) slack. Stitch seams with fiberglass thread.
 - 1. Flexible connections are not required where duct connects to air-handling equipment with internally isolated fans.
- B. Install bird and insect screens in outdoor air connections.

3.22 INSTALLING MANUFACTURED UNITS

- A. Provide necessary devices to balance the air flow to produce air quantities at outlets as indicated on the drawings.

- B. Provide balancing point stations where required for air balancing. Coordinate work with requirements of Section 230593, Testing, Adjusting, and Balancing; final locations shall be as directed by the balancing and testing subcontractor. Stations shall consist of test holes spaced 6 inches (150 mm) on centers across bottom or side of duct. Install test holes before ducts are insulated.
- C. Provide turning vanes in 90-degree square elbows.
- D. Provide spin-in or dovetail fittings as indicated on the drawings.
- E. Installing duct access doors:
 - 1. Install duct access doors in ductwork for access to fire dampers, smoke dampers, ATC dampers, controls, vortex dampers, duct coils, control devices, and any other devices, equipment, or components requiring maintenance, service, or adjustment and located inside ducts or adjacent equipment.
 - 2. Provide OSHA-approved labels on doors enclosing fire protection devices. Labels shall have lettering at least 1/2 inch (13 mm) high describing the protection device enclosed.
 - 3. Duct access doors to kitchen exhaust ducts shall comply with NFPA 96 as follows:
 - a. Openings shall be in the sides of the duct.
 - b. In horizontal sections the lower edge of the opening shall be not less than 1.5 inches (38 mm) from the bottom of the duct.
 - c. Doors shall be constructed of the same material and thickness as the duct and shall be greasetight when in place.
- F. Installing sound attenuator:
 - 1. Where multiple units are used, seal joints after making connections. Provide steel bands around multiple units. Install duct-mounted units with transitions where required, and pressure test with ductwork.
- G. Installing air control devices:
 - 1. Install manual volume dampers, volume extractors, and other devices at locations indicated on drawings and where required to properly balance the systems and to deliver the air quantities indicated. Each damper and device shall have substantial operators of proper size with locking facilities. Volume dampers shall be equipped with locking type regulators.
 - 2. Install automatic control dampers.

3.23 INSTALLING FIRE AND SMOKE DAMPERS

- A. Fire and smoke dampers are an integral part of the rated partition or floor being penetrated. Install sleeves and dampers before beginning installation of the duct system being connected. Do not begin installing ducts until rated assembly, including installed dampers, has been completed.
- B. Install fire and smoke dampers where indicated and in accordance with the applicable requirements of the following:
 - 1. Details on drawings.
 - 2. NFPA requirements.
 - 3. Local building code.
 - 4. Manufacturer's UL-approved installation instructions.
 - 5. SMACNA-05.

- C. Install fire and smoke dampers in sleeves. Coordinate with other trades to properly frame openings so that damper and sleeve assembly can be secured in partition or floor.
 - 1. Do not use dampers and sleeves as a lintel for supporting the wall above the damper. Provide separate steel angles on both sides of wall or floor slab to hold damper and sleeve firmly in place.
 - 2. Sleeve thickness and retaining angle size are contingent on type of duct connection, duct size and damper manufacturer's requirements. See SMACNA recommendations and NFPA requirements.
- D. Coordinate voltages with manufacturer of motorized dampers.
- E. After damper installation is complete and required ductwork connected, test operation of damper by releasing holding mechanism to see that damper operates freely and properly and closes tight. Make adjustments if required and reset holding mechanism.

END OF SECTION 233300

SECTION 233400 - HVAC FANS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Exhaust, circulating, and supply fans.
- B. Accessories.

1.14 RELATED SECTIONS

- A. Curbs: Section 230506.
- B. Vibration control supports: Section 230548.
- C. Motors: Section 230513.
- D. Controls: Sections 230901 through 230913.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Shop drawings detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Reports of specified factory tests.
- C. Product data: Include rated capacities of each unit, weights (shipping, installed, and operating), furnished specialties, accessories, and the following:
 - 1. Certified fan performance curves with system operating conditions indicated. Include static pressure, brake horsepower, and static efficiency plotted against air volume.
 - 2. Motor ratings and electrical characteristics, and motor and electrical accessories.
 - 3. Material gages and finishes, including color charts.
 - 4. Dampers, including housings, linkages, and operators.
- D. Wiring diagrams detailing power and control wiring and differentiating clearly between manufacturer-installed and field-installed wiring.
- E. Maintenance data as required in Division 01 and Section 230101.
- F. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.

1.40 QUALITY ASSURANCE

- A. Fans shall be tested and rated in accordance with the applicable AMCA Standard Test Code and Certified Rating Program and bear AMCA Certified Air Rating Seal.

- B. Fan selections shall be made to the right of the peak static pressure point, but not on any “flat” portion of the fan curve. Generally, fan selection shall be in the 50 percent to 80 percent range of wide open volume.
- C. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.
- D. UL label and local testing (if required): Section 230500, Common Work Results for HVAC.

1.71 COORDINATION

- A. Coordinate the installation of roof curbs, supports, and roof penetrations. Fan installation shall not reduce weathertightness of roof nor violate roof warranty.
- B. Coordinate colors selected for roof-mounted fans with colors of other roof-mounted equipment.

1.91 EXTRA MATERIALS

- A. Provide adjustments in drives and sheaves and belts as required at time of system balancing to obtain the airflow and static pressure indicated on drawings.

PART 2 - PRODUCTS

2.30 FANS, GENERAL

- A. Fan size, capacity, class, arrangement, accessories and discharge shall be as scheduled on the drawings.
- B. Motors shall meet the requirements of Section 230513, Common Motor Requirements for HVAC Equipment, including power factor and efficiency.
- C. Belt drives and exposed rotating shafts shall be provided with guards meeting OSHA and MOSHA requirements.
- D. Fans shall have self-aligning, ball-type bearings designed for thrust load, and grease fittings shall be accessible for relubrication. Fans shall be statically and dynamically balanced.
- E. Motors for belt-driven units shall have adjustable variably pitched cast iron sheaves to allow a 10 percent increase or reduction in speed. Belts shall be sized for minimum 150 percent brake horsepower (bhp).
 - 1. Include one change in drive sheave for each unit if necessary to obtain correct air quantities at time of testing, adjusting, and balancing.

2.34 EXHAUST, CIRCULATING, AND SUPPLY FANS

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified Acme Engineering and Manufacturing product, or comparable product by one of the following:
 - 1. Aerovent, a Twin City Fan Company
 - 2. Acme Engineering and Manufacturing
 - 3. Greenheck Fans.
 - 4. Jenco Fan.
 - 5. Loren Cook, Inc.
 - 6. Penn Barry.

7. Twin City Fans and Blowers.

- B. Roof centrifugal ventilator: Fan wheels shall be of the centrifugal backward curved non-overloading airfoil design, direct or V-belt drive as scheduled. Fan wheel and fan housing shall be of all-aluminum construction, with motor and drive assembly located out of exhaust airstream in separate compartment that is forced-air-cooled with outdoor air. Exposed fasteners shall be stainless steel. Fan shaft and hub shall be zinc-phosphate coated.
- C. Roof upblast kitchen exhaust fan: Fan wheels shall be of the centrifugal, backward-inclined non-overloading airfoil design, direct or belt drive as scheduled. Fan wheel and fan housing shall be of all-aluminum construction, with motor and drive assembly located out of exhaust airstream in separate compartment that is forced-air-cooled with outdoor air. Exposed fasteners shall be stainless steel. Fan shaft and hub shall be zinc-phosphate coated. Kitchen exhaust fans shall be U.L. listed for restaurant exhaust, conforming to NFPA 96, and shall be provided with grease trough and heat shield.
- D. In-line ceiling or wall fan: Blower of steel construction with sound-absorbing lined housing, easily disassembled for service and maintenance, anodized aluminum or baked-enamel-finished steel intake grille, quiet operation, twin squirrel-cage blower wheels and built-in backdraft damper.

2.70 ACCESSORIES

- A. Bird and insect screens: Specified in Section 233300, Duct Accessories.
- B. A disconnecting switch without overload protection shall be included under the weather hood of roof-mounted units, completely factory-wired to motor. Motors for directly driven units shall be provided with solid-state variable speed control, unless otherwise indicated on the drawings.
- C. Provide each unit with self-operating aluminum backdraft damper and frame unless indicated otherwise on the drawings. Damper blades shall operate in unison and shall be counterbalanced or otherwise provided with facilities to positively open under fan suction and to close tight when subject to backdraft.
- D. Identification: Each fan shall be identified with a fan number no less than 0.5 inch high, as shown in the fan schedule, on an aluminum strip riveted to hood of roof fans and on the motor side of frame for wall fans.

PART 3 - EXECUTION

3.20 INSTALLATION, EXHAUST, CIRCULATING, AND SUPPLY FANS

- A. Fans shall be installed in compliance with the manufacturer's recommendations. Ventilating and ceiling exhaust fans shall be supported from the building structure, not attached to the ceiling suspension members or discharge grille system.
- B. Roof fans shall be attached to side of roof curbs using 3/16-inch (4.8-mm) cadmium-plated bolts and nuts or screws, as required, on a maximum of 8-inch (205-mm) centers and a minimum of 8 bolts or screws per fan unit. Use 1-inch minimum diameter aluminum washers with stainless-steel lockwashers under bolt or screw heads.
- C. Coordinate with air balancing and provide adjustments, sheaves, and belts as required in Part 1 above to obtain the airflow and static pressure indicated on the drawings.

3.21 KITCHEN EXHAUST FANS

- A. Curb height: No less than 18 inches (460 mm), and high enough that top of fan is at least 40 inches (1016 mm) above roof surface.
- B. Welded duct shall extend through curbs to top of curb.

3.23 ACCESSORIES

- A. Fans without supply duct on fan inlet shall be provided with bird screens.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 230500, provide operating instructions.
- B. Provide at least 4 hours of additional instruction time for the equipment specified in this section.

END OF SECTION 233400

SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Ceiling- and wall-mounted diffusers, registers, and grilles.

1.14 RELATED SECTIONS

- A. Louvers: Section 233714.
- B. Fire and smoke dampers: Section 233300.
- C. Automatic control dampers: Section 230907.
- D. Balancing: Section 230593.

1.20 REFERENCES

- A. NFPA 90A: Standard for the Installation of Air-Conditioning and Ventilating Systems.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: Each type of diffuser, register and damper, and grille, including frames and accessories, and performance data.
- C. Shop drawings:
 - 1. Schedule, including size, location, function, and finish of each diffuser, register, and grille.
 - 2. For each air control device, provide information required to balance the system. Include the factor for each size and type of device for converting velocity to volume.
 - a. Include this information in Operating and Maintenance Manuals.
- D. Samples: Manufacturer's complete line of color chips for anodized aluminum linear grilles and diffusers.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Grilles, registers and diffusers:
 - 1. Hart and Cooley Inc.
 - 2. Krueger.
 - 3. Metalaire.
 - 4. Nailor Industries, Inc.
 - 5. Price Company.
 - 6. Titus Products.

2.21 DIFFUSERS, REGISTERS, AND GRILLES

- A. Devices of one of the named manufacturers, with performance data, characteristics, features, and accessories of the model or type specified or indicated on the drawings. Model numbers specified below are Krueger except as noted otherwise.
- B. See architectural drawings for type of walls and ceilings where diffusers, grilles, and registers are required. Coordinate margin and frame of each device with the substrate in which it will be installed. Where devices are installed in suspended ceilings, assure that they will fit correctly in the type of suspension supports shown or specified.
- C. Materials and finish:
 - 1. Construction:
 - a. Steel where mounted in ceilings.
 - b. Either aluminum or steel where mounted in walls near ceiling.
 - c. Heavy-duty steel where mounted in walls near floor.
 - d. Welded or mechanically fastened cores in diffusers located in gymnasium.
 - 2. Aluminum devices shall be all aluminum construction, including dampers, where specifications call for aluminum or stainless steel ductwork.
 - 3. Finish: Manufacturer's standard white enamel, suitable for final finish or for field painting, unless indicated otherwise.
- D. Where narrow margin grilles and registers are specified or indicated on the drawings, they shall be provided with mounting frames except where mounted on ductwork.

2.22 SUPPLY DIFFUSERS

- A. Throw length is based on performance data of the scheduled or specified manufacturer and model. Select units of other manufacturers whose performance data meet the required conditions. Throw direction of square and rectangular ceiling diffusers shall be four-way unless otherwise indicated on the drawings.
- B. Square and rectangular ceiling diffusers: Series SH with square, rectangular, or round neck and removable core. Each unit shall have a straightening grid. The grids shall be set at right angles to one another.
 - 1. Frame Style 23 (panel diffuser): Diffusers mounted in nominal 24 by 24-inch (600 by 600-mm) or 24 by 48-inch (600 by 1200-mm) flat steel panels as indicated on the drawings, to lay into suspended ceiling grid of acoustical ceilings.
 - 2. Frame Style 22 (surface mount): Diffuser with flat frame to mount at underside of plaster or gypsum wallboard ceilings.
- C. Round, adjustable diffuser with round neck: RA2 series, surface-mounted frame, 360 degree discharge with infinitely field-adjustable vane settings for discharge pattern from vertical to horizontal, combination air extractor/damper and grid with concealed adjustment, duct-mounted straightening grid (shipped loose for field installation).

2.23 SUPPLY GRILLES AND REGISTERS

- A. For registers, provide opposed-blade dampers with linkage and adjustment through grille face with a screwdriver or allen wrench.

- B. Wall-mounted near ceiling: Grilles 880H (steel) 5880H (aluminum); double deflection with horizontal face bars, minimum 1.25-inch (32-mm) overlap margin.
- C. Ceiling-mounted: Register 5180-OBD (aluminum) 180-OBD (steel), individually adjustable curved air deflection blades, 1-, 2-, 3-, or 4-way air pattern as indicated on the drawings, minimum 1.25-inch (32-mm) overlap margin.

2.24 RETURN AND EXHAUST GRILLES AND REGISTERS

- A. For registers, provide opposed-blade dampers with linkage and adjustment through grille face with a screwdriver or allen wrench.
- B. Ceiling-mounted and wall-mounted near ceiling: Grille S-80H (steel) or S-580H (aluminum). Fixed horizontal face bars set at 35 to 45 degrees deflection, minimum 1.25-inch (32-mm) margin.
- C. Wall-mounted near floor: Grille S-480-H, heavy-duty steel construction, 14 gage fixed horizontal face bars set at 30 to 40 degrees deflection, spaced on 0.5 to 0.7-inch (13 to 18-mm) centers, and 14 gage vertical support bars on maximum 8-inch centers, minimum 1.25-inch (32-mm) margin.

2.25 TRANSFER GRILLES

- A. Ceiling-mounted and wall-mounted near ceiling: S80H (steel) or S-580H (aluminum), fixed horizontal face bars set at 35 to 45 degrees deflection, minimum 1.25-inch margin.
- B. Wall-mounted near floor: S-480-H (steel), heavy duty, 14 gage fixed horizontal bars set at 30 to 40 degrees deflection, spaced on 0.5- to 0.7-inch (13 to 18-mm) centers, and 14 gage vertical support bars on maximum 8-inch (205-mm) centers, minimum, (32-mm) margin.

PART 3 - EXECUTION

3.21 INSTALLING GRILLES, REGISTERS AND DIFFUSERS

- A. Securely attach grilles, registers, and diffusers in place. Do not install the grilles and registers until duct interiors have been painted as specified in Section 230500, Common Work Results for HVAC.
- B. Install all air control devices complete with the accessories specified, securely attached in position. Make operating devices accessible.
- C. Adjust diffuser straightening grids to provide uniform air distribution above diffuser face.
- D. Adjust supply register deflectors to provide uniform air distribution to the areas served.

END OF SECTION 233713

SECTION 233714 - LOUVERS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Louvers as indicated on the architectural drawings.

1.14 RELATED SECTIONS

- A. Ductwork: Section 233113.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: Louvers.
- C. Samples: For finish selection, manufacturer's complete line of color chips.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Specified models, with selected options and accessories, are intended to set a standard for construction, materials, finish, and engineering performance. Products of other acceptable manufacturers must meet all requirements.
 - 1. Air Balance, Inc.
 - 2. Airline Products Company
 - 3. Airolite Company
 - 4. All-Lite Company
 - 5. American Warming and Ventilating, Inc.
 - 6. Arrow United Industries
 - 7. Ruskin Air & Sound Control

2.31 LOUVERS

- A. Provide louvers with free area, pressure drop, and water penetration as published in manufacturer's literature for the specified models, tested in accordance with AMCA Standard 500. Model(s):
 - 1. Louvers: Ruskin GFL800 stationary louver.
- B. Construction: 4-inch deep, 0.080-inch thick extruded aluminum frame, box or flange mounts. Extruded aluminum, 0.063-inch thick J-style blades, positioned at 45 degree angles and spaced approximately 5 inches, center to center.
- C. Bird screen: ASTM E 437, general industrial-use wire cloth, Grade C, medium light or heavier, nominal two-inch mesh and 0.063-inch wire diameter, aluminum, in removable frame. Screen adds approximately 1/2 inch (13 mm) to louver depth.

- D. Accessories: Angles, moldings, cover plates, anchor bolts, and other items required for securing louvers in openings as detailed on the drawings, aluminum or stainless steel. Exposed accessories shall be finished to match the louvers.
- E. Sizes: Shown on drawings.
- F. Finish: Manufacturer's standard factory-applied baked enamel or fluoropolymer finish, color to be selected.
- G. Guard: Provide guards for louvers in locations described in Part 3 below. Lattice design with square openings, 60 percent free area, nominal 1/8-inch thick aluminum, clear anodized finish, with countersunk screw fasteners.

2.32 BLANK-OFF PANELS

- A. Laminated metal-faced panels, thickness 2 inch, with aluminum facing sheets front and back 0.032 inches thick, and rigid fiberglass insulation.
- B. Finish: Same as louvers.

PART 3 - EXECUTION

3.20 INSTALLING LOUVERS

- A. Place each louver plumb, level, and in alignment with adjacent work.
- B. Use concealed anchorage where possible. Provide brass or lead washers on screws where required to protect metal surface and to make weathertight connections.
- C. Form closely fitted joints with exposed connections accurately located and secured.
- D. Install concealed gaskets, flashings, joint fillers, and insulation where required to make louvers weathertight. Comply with requirements of Division 07.
- E. Blank off any section of louver not required to be open.
- F. Install guard on exterior face of louvers where sill is within 6 feet of finished grade.

3.70 ADJUSTING

- A. Restore louvers damaged during installation and construction period so that no evidence remains of correction work.
- B. Clean and touch up minor abrasions in finishes with air-dried coating matching color and gloss of, and compatible with, factory-applied finish.

END OF SECTION 233714

SECTION 234100 - PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.10 SUMMARY

- A. Filters for temporary service during construction are required in the equipment sections, including changes required to meet the requirements of Indoor Air Quality Management in Division 01.
- B. Provide two sets of filters for every item of equipment requiring filters, as follows:
 - 1. Filters for regular service, installed before air balancing.
 - 2. Filters for regular service, provided as extra materials for future use.

1.14 RELATED SECTIONS

- A. Unit heaters: Section 238239.
- B. Ductless split-system units: Section 238127.
- C. Fan-coil units: Section 238219.
- D. Air-handling units: Section 237322.
- E. Variable-refrigerant system: Section 238128.
- F. Packaged rooftop air-conditioning units: Section 237413.
- G. Energy recovery and dedicated outdoor air units: Section 237200.

1.20 REFERENCES

- A. ASHRAE 52.1: Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices used in General Ventilation for Removing Particulate Matter.
- B. ASHRAE 52.2: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
- C. ARI 850: Commercial and Industrial Air Filter Equipment.

1.21 DEFINITIONS

- A. MERV: Minimum Efficiency Reporting Value as determined by ASHRAE 52.2.
- B. Temporary service: Operation of equipment during the construction period, before air balancing.
- C. Regular Service: Operation of equipment during air balancing and in normal use during occupancy.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data:

1. For filters, include filter ratings, rated flow capacity, and fire classification.

C. Shop drawings: Illustrate assemblies and attachments.

D. Closeout submittals: As required for Operating and Maintenance Manuals in Division 01 and Section 230101, provide a schedule of locations of filters, identifying equipment and filter types and sizes, including prefilters and final filters.

1.40 QUALITY ASSURANCE

A. Provide all filters for regular service from a single manufacturer.

B. Test filters by methods described in ASHRAE 52.1 and ASHRAE 52.2.

C. Comply with ARI 850.

1.92 EXTRA MATERIALS

A. Disposable and throwaway filters: For each filter included for regular service, provide one extra filter. Identify each filter with its name and intended location and use.

B. Provide filters and media in protective packaging, with identifying labels or markings.

C. Except as otherwise required in Division 01, deliver to location designated by Owner, and shelve or stack as directed.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Basis-of-design products: Subject to compliance with requirements, provide specified or scheduled products, or comparable product by one of the following:

1. Filters:

- a. AAF International.
- b. Airguard; Clarcor Air Filtration Products
- c. Camfil Farr
- d. Flanders Filters, Inc.

2. Filter Gages:

- a. Dwyer Instruments, Inc.
- b. H.O. Trerice Co.
- c. Miljoco Corporation
- d. Weksler Instruments

2.20 FILTERS, GENERAL

A. Coordinate with approved manufacturers of the various approved air handling units and equipment for filter size and thickness required.

- B. Thickness: Generally, large air handling units shall have filters 2 inches and more thick. Smaller units such as fan-coil units may be limited to filters 2 inches thick.
- C. Filter face areas: As scheduled, or equivalent to one square foot for each 300 cfm.

2.21 THROWAWAY FILTERS

- A. FS F-F-310, Type I throwaway frame and media, Grade B high dust holding capacity, of size and thickness to fit units.

2.23 DISPOSABLE FILTERS, MERV 8

- A. Camfil Farr "Farr 30/30", Class 2, thickness 4, 2, or 1 inches, and size required for each location, disposable.
- B. Rating in accordance with ASHRAE 52.1:
 - 1. Average efficiency: 25 to 30 percent.
 - 2. Average arrestance: 90 to 92 percent.
- C. Rating in accordance with ASHRAE 52.2: MERV 8
- D. UL 900: Class 2.
- E. Medium: Non-woven, reinforced cotton and synthetic fabric, pleated.
- F. Medium support grid: Welded wire with an effective open area not less than 96 per cent, bonded to medium.
 - 1. Performance: Medium shall not oscillate nor pull away from support grid.
 - 2. Design: Tapered radial pleats, supporting medium both vertically and horizontally.
- G. Enclosing frame: High-wet-strength beverage board, with diagonal supports bonded to media pleats. Filter pack continuously bonded to inside of frame so that no air leaks around edges.

2.25 DISPOSABLE FILTERS, MERV 13

- A. Camfil (Farr) Opti-Pac high-efficiency, deep-pleated, 4-inch disposable type. Each filter assembly shall consist of a high-efficiency filter, medium retainer and holding frame.
- B. Medium: Microfine glass media in a close-pleat design bonded into a beverage board holding frame.
- C. Rating in accordance with ASHRAE 52.1: Average efficiency 80-85 percent, and average arrestance not less than 98 percent.
- D. Rating in accordance with ASHRAE 52.2: MERV 13.
- E. The initial resistance to airflow shall not exceed 0.5 inch wg at 500 fpm.
- F. UL 900: Class 2.

2.33 FILTER GAGE

- A. Gage: Equal to Dwyer "Magnehelic", Series 2000, range zero to 3 inches wg, with divisions of 0.10 inch.
- B. Accessory package: To adapt the magnehelic gage for use as a filter gage. Package includes aluminum surface-mounting bracket with screws, two 5-foot lengths of 0.25-inch aluminum tubing, two static pressure tips, and two molded plastic vent valves, with integral compression fittings on both tips and valves.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Before startup of each item of equipment requiring a filter, install filters for temporary service.
 - 1. Generally, provide throwaway filters for temporary service.
 - 2. On equipment with prefilter and final filter, provide only the specified prefilter for temporary service.
- B. Immediately prior to air balancing, remove temporary filters and install filters required for regular service.

3.22 INSTALLING FILTER GAGE

- A. Mount across filter section in accordance with manufacturer's instructions.

END OF SECTION 234100

SECTION 235100 - BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Listed double-wall vents for condensing type equipment.

1.14 RELATED SECTIONS

- A. Structural support: Division 03, Concrete.
- B. Roof curbs: Section 230506.
- C. Insulation: Section 230716.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data.
- C. Shop drawings: For vents, breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, hangers, and location and size of each field connection.
 - 2. For installed products indicated to comply with design loads, include calculations and structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 3. For field-fabricated metal breechings and chimneys, include details of access doors and dampers.
- D. Certifications: Welding certificates.
- E. Warranties: Special warranties specified in this section.

1.40 QUALITY ASSURANCE

- A. Source limitation: Obtain listed system components through one source from a single manufacturer.
- B. Welding: qualify processes and welders according to AWS D1.1 for hangers and supports, and AWS D9.1 for shop and field welding of joints and seams in vents, breechings, and stacks.
- C. Certified sizing calculations: Manufacturer shall certify venting system sizing calculations.

1.49 COORDINATION

- A. Coordinate installation of roof curbs, equipment supports, and roof penetrations, including work specified in Division 07.

1.80 WARRANTY

- A. Special warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within the warranty period. Failures include, but are not limited to, structural failures caused by expansion and contraction.
- B. Warranty period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.21 LISTED SPECIAL GAS VENT

- A. Category II or IV flues:
 - 1. Category II: Non-positive pressure and condensing type.
 - 2. Category IV: Positive pressure and condensing type.
- B. Manufacturers:
 - 1. Heat-Fab Inc.
 - 2. Metal-Fab, Inc.
 - 3. Schebler Chimney Systems
- C. Double-wall metal vents rated for 40 inches and tested according to UL 1738 and rated for 550 degrees F (288 degrees C) continuously, with positive or negative flue pressure complying with NFPA 211 and suitable for condensing-gas appliances.
- D. Construction: Inner shell and outer jacket separated by at least a 1.0-inch (25-mm) air space.
- E. Inner shell: ASTM A 959 Type 29-4C stainless steel.
- F. Outer jacket: Inside the building, aluminized steel; outside the building, Type 430 stainless steel.
- G. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spaces, and fasteners; fabricated from similar materials and designs to the vent-pipe straight sections; all listed for the same assembly.
 - 1. Termination: Round chimney top designed to exclude 98 percent of rainfall.

PART 3 - EXECUTION

3.02 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.20 INSTALLATION OF LISTED VENTS, CHIMNEYS, AND BREECHINGS

- A. Systems shall be designed and installed to compensate for flue-gas-induced thermal expansion and contraction.
- B. Locate to comply with minimum clearances from combustibles and minimum termination heights, according to product listing or NFPA 211, whichever is most stringent, but not less than 8 feet (2.5 m) above roof.
- C. Support at intervals recommended by manufacturer not to exceed appliance loading.
- D. Provide sections, fittings, and accessories required to accomplish the installation indicated on the drawings. Install continuously from appliance outlets into bird-proof termination including roof support assembly.
- E. Install system in full compliance with the terms of its UL listing, with the manufacturer's installation instructions, and with national and local building codes for such installations.
- F. Install drain section and exit cone as indicated on the drawings.
- G. Install drain piping from drain section to nearest floor drain and as shown on drawings.
- H. Make 90-degree changes in direction with Ts and plugs to provide cleanouts.
- I. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.
- J. Provide certified T section, straight sections, flashing and counterflashing, double angle interior bracing, insulated thimble, and other pieces and accessories required to accomplish installation shown on drawings.

3.75 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 interior of breechings, 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 vents, breechings, chimneys, and stacks that are not completed or connected to equipment.

END OF SECTION 235100

SECTION 235216 - CONDENSING BOILERS

PART 1 - GENERAL

1.10 SUMMARY

- A. This section includes packaged, factory-fabricated and -assembled, gas-fired, fire-tube stainless-steel condensing boilers, trim, and accessories for generating hot water.
- B. Boiler accessories, including vent kits and combustion-air intake piping.
- C. Stand-alone boiler control and sequencing device for multiple boilers.

1.14 RELATED SECTIONS

- A. Burner startup and service: Section 230100.
- B. Gas piping: Section 231123.

1.27 PERFORMANCE REQUIREMENTS

- A. Minimum boiler efficiency performance based on 110 degrees F return water temperature:
 - 1. 97 percent at low fire.
 - 2. 93 percent at mid fire.
 - 3. 90 percent at high fire.

1.30 SUBMITTALS

- A. Product data: Include performance data, operating characteristics, furnished specialties, and accessories.
- B. Shop drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
 - 1. For installed products indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 2. Design calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - 3. Vibration isolation base details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
 - 4. Wiring diagrams: Detail power, signal, and control wiring.
- C. Source quality-control test reports.
- D. Startup service reports.
- E. Operation and maintenance data: For condensing boilers to include in emergency, operation, and maintenance manuals.
- F. Certifications:
 - 1. As required in Section 230100 for burner startup and service.

2. Maryland State Boiler Inspection Certificate.

- G. Service agreement specified in "Maintenance Service" below, executed to the Owner and notarized.

1.40 QUALITY ASSURANCE

- A. Product options: Drawings indicate size, profiles, and dimensional requirements of condensing boilers and are based on the specific system indicated. Refer to Division 01.
- B. Electrical components, devices, and accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. ASME compliance: Fabricate and label condensing boilers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- D. ASHRAE/IESNA 90.1 Compliance: Condensing boilers shall have minimum efficiency according to Table 10-8.
- E. UL compliance: Test condensing boilers to comply with UL 795, "Commercial-Industrial Gas Heating Equipment."
- F. Flue gas composition and temperature shall meet the requirements specified in Section 230100, Operation and Maintenance of HVAC.
- G. UL label and local testing (if required): As specified in Section 230500, Common Work Results for HVAC.
- H. Gas regulators shall have emergency exposure rating of 15 psi. Regulator shall not suffer internal damage at this overpressure.

1.42 REGULATORY REQUIREMENTS

- A. Before construction begins, obtain and complete forms, and apply for the permit and registration of the burners and boilers with the authority having jurisdiction.
- B. Components and installation, including sequences of operation, shall comply with the applicable requirements of ASME CSD-1, Controls and Safety Devices for Automatically Fired Boilers.
- C. Costs of complying with these and other applicable regulatory requirements shall be included in the Contract sum.

1.49 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.92 MAINTENANCE SERVICE

- A. In addition to the startup service specified in Section 230100, the qualified service and maintenance organization shall provide a 2-year service agreement covering all parts and labor for regular service, emergencies, and repairs.

- B. Regular service: One visit at annual startup of boilers and a second visit at the end of the heating season.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply for product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.31 FIRE-TUBE CONDENSING BOILERS

- A. Basis of design product: Subject to compliance with requirements, provide the scheduled unit or comparable product by one of the following:
 - 1. Fulton Boiler Works, Inc.
 - 2. Viessman Manufacturing Company, Inc.
 - 3. Aerco International, Inc.
- B. Description: Factory-fabricated, -assembled, and -tested fire-tube condensing boiler with stainless-steel 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. Fire-tube boiler components:
 - 1. Heat exchanger: Nonferrous, stainless steel, corrosion-resistant combustion chamber.
 - 2. Pressure vessel: Stainless steel with welded heads and tube connections.
 - 3. Burner: Natural gas, forced draft.
 - 4. Gas train: Combination gas valve with manual shutoff and pressure regulator. Include 100 percent safety shutoff with electronic flame supervision.
 - 5. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
 - 6. Casing:
 - a. Jacket: Sheet metal, with snap-in or interlocking closures.
 - b. Control compartment enclosures: NEMA 250, Type 1A.
 - c. Finish: Baked-enamel protective finish.
 - d. Insulation: Minimum 2-inch- (50-mm-) thick fiberglass insulation surrounding the heat exchanger.
 - e. Combustion-air connections: Inlet and vent duct collars.
 - 7. Mounting base to secure boiler to concrete pad with neoprene vibration isolation provided between base and pad.
 - 8. Condensate trap: Cast-iron body with stainless-steel internal parts.
 - 9. PH neutralization kit: Polyethylene container, 6-1 lb. bags of magnesium oxide neutralizing medium, 1.5 inch NPT plastic pipe fittings.

2.32 HOT-WATER BOILER TRIM

- A. Include devices sized to comply with ANSI B31.9, "Building Services Piping."

- B. Aquastat controllers: Operating, firing rate, and high limit.
- C. Safety relief valve: ASME rated. 100 psig (690 kPa).
- D. Altitude and temperature gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is at approximately 50 percent of full range.
- E. Boiler air vent: Automatic.
- F. Drain valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.

2.33 BURNER OPERATING CONTROLS

- A. Description: To maintain safe operating conditions, burner safety controls limit the operation of burner.
 - 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.
 - 4. Alarm bell: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
- B. Provide an independent controller for staging and sequencing all boiler burners.
 - 1. Mod Sync controller or equal product by a similar manufacturer, complete with BACnet protocol.

2.34 BOILER OPERATING CONTROLS

- A. Boiler operating controls shall include the following devices and features:
 - 1. Control transformer: 115 V.
 - 2. Sequence of operation: Electric, factory-fabricated, and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 0 deg F (minus 17 deg C) outside-air temperature, set supply-water temperature at 200 deg F (93 deg C); at 60 deg F (15 deg C) outside-air temperature, set supply-water temperature at 140 deg F (60 deg C).
 - a. Include automatic, alternating-firing sequence for multiple boilers.
- B. Building management system interface: Factory-installed hardware and software to enable building management system to monitor and control hot-water set point and display boiler status and alarms.

2.35 VENTING AND OUTDOOR AIR INTAKE KITS

- A. Vent kit: ASTM A 959, Type 29-4C, stainless-steel, double-wall, vertical vent terminal, roof passage thimble, indoor wall plate, vent adapter, condensate trap, and sealant.

- B. Outdoor combustion-air intake: Schedule 40 PVC. Pipe, fittings, and solvent cement shall conform to ANSI and ASTM standards.

2.70 ACCESSORIES

- A. Device plate for emergency boiler switch: As specified in Section 230500, engraved plastic, red letters on white background, reading "EMERGENCY BURNER DISCONNECT."

2.90 SOURCE QUALITY CONTROL

- A. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code: Section I, for high-pressure boilers and Section IV, for low-pressure boilers.

PART 3 - EXECUTION

3.02 EXAMINATION

- A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.

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

3.20 BOILER INSTALLATION

- A. Install boilers level on concrete base. Concrete base is specified in Section 230529 and concrete materials and installation requirements are specified in Division 03.

- B. Concrete bases: Anchor boilers to concrete base.

- 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of 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 supported equipment.
 - 5. Cast-in-place concrete materials and placement requirements are specified in Division 03.

- C. Install gas-fired boilers according to NFPA 54.

- D. Assemble and install boiler trim.

- E. Install electrical devices furnished with boiler but not specified to be factory mounted.

3.22 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

- B. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Division 23 Section "HVAC Piping Specialties."
- C. Connect gas piping full size to boiler gas-train inlet with union.
- D. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.
- E. Install piping from safety relief valves to nearest floor drain.
- F. Connect breeching full size to boiler outlet.
- G. Install piping adjacent to boiler to allow service and maintenance.
- H. Ground equipment according to Division 26 Section "Grounding and Bonding."
- I. Connect wiring according to Division 26 Section "Wires and Cables."
- J. 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.

3.61 STARTUP SERVICE

- A. Engage a factory-authorized service representative to test, inspect, and adjust boiler components and equipment installation and to perform startup service.
- B. Perform installation and startup checks according to manufacturer's written instructions.
- C. Leak test: Hydrostatic test. Repair leaks and retest until no leaks exist.
- D. Operational test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
- E. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- F. Adjust initial temperature set points.
- G. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- H. Occupancy adjustments: When requested within 24 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose, without additional cost.
- I. Prepare written report that documents testing procedures and results.

3.81 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain condensing boilers. Refer to Section 230500.

END OF SECTION 235216

SECTION 236313 - AIR-COOLED REFRIGERANT CONDENSING UNITS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Air-cooled condensing units designed for installation outdoors.

1.14 RELATED SECTIONS

- A. Refrigeration piping: Section 232300.
- B. Equipment supports: Section 230529.
- C. Foundation: Section 230529.
- D. Motor: Section 230513.
- E. Vibration control supports: Section 230548.
- F. Refrigeration equipment service, warranty, and maintenance: Section 230100.
- G. Associated equipment: Sections 238219.

1.27 PERFORMANCE REQUIREMENTS

- A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted under the article "Acceptable Manufacturers," ascertain that it will:
 - 1. Perform to the scheduled and specified capacities.
 - 2. Make no additional demands on other systems such as domestic, heating and chilled water, or electricity.
 - 3. Meet or exceed all specified requirements.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data:
 - 1. Condensing unit and accessories.
 - 2. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
 - 3. Product data shall verify compliance with CEE efficiency requirements.
- C. Shop drawings:
 - 1. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, including plans and sections showing any changes in wiring, arrangement, or access made necessary to accommodate the unit proposed.

2. Shop drawings shall show complete dimensions of complete assembled unit with accessories. Include dimensions and configuration as required to coordinate with roof structure and deck.
3. Include wiring diagrams showing factory- and field-wiring for each unit.
4. Provide design of refrigeration piping prepared by manufacturer of the refrigeration compressor. Show oil traps and accessories specified in Section 232300, Refrigerant Piping, as well as those required by the manufacturer.
5. Provide equipment balance curve graph showing balance point of condensing unit in connection with the DX coil specified in the associated air-handling equipment.

1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 230500, Common Work Results for HVAC.
- B. Regulatory requirements:
 1. ICC: HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.
 2. COMAR 14.26.03: Packaged equipment with over 20 tons of cooling capacity shall meet the Tier 2 requirements for minimum efficiencies for unitary commercial air conditioners or heat pump units of the Consortium for Energy Efficiency (CEE), in effect on 1 January 2002.
 3. EPA: Refrigerant: HFC-410a.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified or scheduled product, or comparable product by one of the following:
 1. Carrier Corporation.
 2. Daikin (McQuay) International.
 3. Trane Co.
 4. York International.
 5. Aeon.
- B. Comply with requirements of article "Performance Requirements" above.

2.21 AIR-COOLED CONDENSING UNITS

- A. Factory-assembled and -tested, designed for use with the specified refrigerant, and ARI certified.
- B. Performance:
 1. Meet scheduled performance requirements and comply with regulatory requirements for efficiency.
 2. With standard controls, unit shall operate at capacity shown on drawings when ambient air (air entering condenser) is within the range from 95 degrees F (35 degrees C) to low ambient temperature of 0 degrees F.
- C. Coil: Nonferrous, with aluminum plate fins mechanically bonded to seamless copper tubes. Coil shall be circuited for subcooling.

1. Provide hail guard for coil protection.
- D. Condenser fans and motors:
1. Fans: Arranged for vertical discharge. Provide safety guard for each fan.
 2. Motors: Permanently lubricated, with Class B motor insulation and inherent protection. Mount on resilient supports.
 3. Include controls to cycle fan for intermediate season operation.
- E. Compressor: Accessible or fully hermetic design, with external or internal spring isolators and reversible oil pump. Compressor shall have mechanical unloading down to the percentage of full capacity, in a minimum number of steps for partial load operation, scheduled on the drawings.
1. Provide minimum one two-stage, digital scroll, or variable speed compressor for each unit.
- F. Controls: Factory-wired.
1. Safety devices: High- and low-pressure switches and compressor overload devices.
 2. Short-cycle protection: Positively acting timer shall prevent compressor from restarting for 3 minutes.
 3. Operating low-pressure cutout (systems 10 tons and larger): When the system cycles off, shall pump out the low side.
 4. Transformer for control circuit.
 5. Devices:
 - a. Discharge line thermostat.
 - b. Oil pressure switch.
 - c. Pressure relief valves.
 - d. Capacity unloader.
 - e. Hot gas muffler.
 - f. Crankcase heater.
 6. Power panel: Factory-installed, containing the main circuit breaker.
 7. Control cabinet: Factory-installed, containing starters with overload protection and control devices.
- G. Casing: Fully weatherproof for outdoor installation, made of galvanized steel, zinc-phosphatized and finished with baked enamel. Provide openings for power and refrigerant connections, removable panel allowing access for servicing, and a hinged access door on the control panel.
- H. Unit supplier shall cooperate with automatic temperature control subcontractor to implement the control sequence shown on the drawings and required by the manufacturer.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Provide refrigerant equipment startup and service by a factory-authorized agent during the correction period as specified in Section 230100.
- B. Set condensing unit on equipment supports with vibration control supports. Securely attach unit to its support.

- C. All relief valves shall be vented to atmosphere with steel pipe or copper tubing in accordance with applicable codes.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 23 0500, provide operating instructions.
- B. Provide at least 2 hours of additional instruction time for the equipment specified in this section.

END OF SECTION 236313

SECTION 236419 - POSITIVE DISPLACEMENT CHILLERS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Scroll compressor air-cooled chillers.

1.14 RELATED SECTIONS

- A. Motors: Section 230513.
- B. Refrigerant piping: Section 232300.
- C. Refrigeration service and maintenance: Section 230100.
- D. Controls: Sections 230901 through 230923.
- E. Foundations: Section 230529.

1.20 REFERENCES

- A. ARI 550/590: Water-Chilling Packages Using the Vapor Compression Cycle.
- B. ASHRAE 15: Safety Code For Mechanical Refrigeration.
- C. NFPA 70: National Electrical Code.
- D. UL 1995: Standard for Safety for Heating and Cooling Equipment.
- E. ASME Boiler and Pressure Vessel Code (BPVC): Rules of safety governing the design, fabrication, and inspection of boilers, pressure vessels and subsystems.

1.27 PERFORMANCE REQUIREMENTS

- A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted under 2.01, "Acceptable Manufacturers," below, ascertain that it will:
 - 1. Perform to the scheduled and specified capacities.
 - 2. Make no additional demands on other systems such as domestic, heating, and chilled water, or electricity.
 - 3. Meet or exceed all specified requirements.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Shop drawings for each chiller:
 - 1. Dimensioned plan and elevation view drawings, required clearances, and locations of field connections.
 - 2. Unit capacity and electrical characteristics showing ratings in accordance with ARI 550/590.

3. Single-line schematic drawing of field-installed electrical connections, indicating chiller components and accessories.
 4. Schematic diagram of control system indicating points for field connection. Diagram shall fully delineate field and factory wiring.
 5. Identify changes in wiring, arrangement or access made necessary to accommodate proposed unit.
- C. Product data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
- D. Certifications:
1. Factory run test signed by company officer.
 2. Factory authorization of service and maintenance agency.
- E. Maintenance data: Installation instructions and operation and maintenance manuals as required in Division 01 and Section 230101.
- F. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, including plans, elevations, sections, and diagrams, showing any changes in wiring, arrangement, or access necessary to accommodate the proposed unit.
- G. Report: Confirm acoustical readings comply with COMAR Title 26 requirements for daytime and nighttime property line noise requirements as measured over a 24-hour period of chiller operation by a qualified, independent acoustical consultant.
- H. Report: Confirm acoustical readings do not exceed 35 dBA in educational spaces, within building, adjacent to chiller as measured over a 12-hour period – from 6:00 am to 6:00 pm – of chiller operation by a qualified, independent acoustical consultant.

1.40 QUALITY ASSURANCE

- A. ASME compliance: Comply with ASME BPVC Section VIII for constructing and testing evaporator and condenser pressure vessels. Stamp with ASME label.
- B. Comply with ASHRAE 15 for chiller design, construction, leak testing, and installation.
- C. Comply with NFPA 70.
- D. Comply with UL 1995.
- E. Chiller equipment shall meet the energy performance requirements of ASHRAE 90.1. Submit with shop drawings, product data that verifies compliance or provide certified performance ratings by a qualified independent testing agency.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Ship unit with protective covering on compressor motor, control center, and unit controls. Cap water nozzles with fitted closures.

1.80 WARRANTY

- A. Provide special warranty as required in Section 230100 for refrigeration equipment, including compressors.

1.92 MAINTENANCE SERVICE

- A. Specified in Section 230100, Operation and Maintenance of HVAC Systems.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Scheduled units are the basis for design of the project. The following listed manufacturers also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article "Product Options" in Section 230101, and submit shop drawings as specified in article 1.30 above.

1. Daikin
2. Trane Company
3. York; Johnson Controls

2.10 MATERIALS

- A. Refrigerant compatibility: Seals, O-rings, motor windings and internal water parts exposed to refrigerants shall be fully compatible with refrigerants and pressure components shall be rated for refrigerant pressures.

2.20 DESCRIPTION

- A. Chillers shall be air cooled with scroll compressors suitable for outdoor use with air cooled condenser.
- B. The contractor shall provide any special accessories required by the manufacturer for the chiller installation that are not shown on the drawings.

2.22 SCROLL COMPRESSORS

- A. Description: Hermetic, refrigerant cooled, induction type, two-pole, with force feed lubrication system, crankcase heater, suction strainer, and suction and discharge line service valves, mounted on vibration isolators.

1. Oil lubrication system: Centrifugal oil pump, strainer, sight glass, and filter.

- B. Refrigerant: HFC 134a or HFC 410a, full operating charge of refrigerant and oil.

2.24 EVAPORATOR

- A. Brazed plate-to-plate type heat exchanger: Parallel stainless steel plates.

1. Refrigerant working pressure: 300 psig (2070 kPa).
2. Water-side working pressure: 150 psig (104 kPa).

- B. Insulation: Factory applied to evaporator, suction lines, and other surfaces where condensation might occur, with 3/4-inch- (19-mm-) thick, flexible closed cell insulation.
- C. Evaporator heater: Factory-installed electric heater with capacity to protect evaporator to minus 20 deg F (minus 29 deg C) ambient temperature. Heater shall be on separate 110V power circuit independent of main unit power.

2.25 REFRIGERANT CIRCUIT ACCESSORIES

- A. Multicompressor units shall have minimum of two refrigerant circuits, each with the following specialties:
 - 1. Suction and discharge shutoff valves.
 - 2. Refrigerant charging connection.
 - 3. Solenoid valve in liquid line.
 - 4. Filter/dryer with replaceable core.
 - 5. Sight glass and moisture indicator in liquid line.
 - 6. Pressure-relief valve.
 - 7. Expansion valves, one per circuit.
- B. Hot-gas bypass: Hot-gas bypass on lead refrigerant circuit. Unit shall operate down to 10 percent of full load capacity. Hot gas capacity shall not exceed limits in ASHRAE 90.1. Include hot gas bypass valve, solenoid valve, and manual shutoff valve.

2.27 AIR-COOLED CONDENSER

- A. Exterior casing: Manufacturer's standard equipment casing coated with corrosion-resistant exterior finish and with removable doors or panels for service and inspection.
- B. Coils: Seamless copper tubing mechanically bonded to aluminum fins. Factory test coils for leaks to minimum test pressure of 425 psig (930 kPa).
- C. Coil grilles: Louvered, galvanized steel mesh.
- D. Fans: Directly driven, statically and dynamically balanced, with fan guards.
- E. Fan motors: Three-phase, integral overload protection, and permanently lubricated bearings.

2.28 CONTROL PANEL

- A. Manufacturer's standard microprocessor-based chiller controls; unit mounted, and factory wired with single-point power connection and control circuit transformer.
- B. Status display: Alphanumeric multi-line display terminal with touch-pad interface. Include the following conditions:
 - 1. Date and time.
 - 2. Operating or alarm status.
 - 3. Operating hours.
 - 4. Entering-chilled-water temperature.
 - 5. Leaving-chilled-water temperature.
 - 6. Evaporator refrigerant temperature.
 - 7. Evaporator pressure.
 - 8. Condenser pressure.

9. Electronic expansion valve position.
 10. Control set points.
 11. Oil temperature pressure.
 12. Percent of maximum motor amperage.
 13. Current limit setpoint.
 14. Number of compressor starts.
- C. Control functions: Include the following:
1. Manual or automatic startup and shutdown time schedule.
 2. Leaving-chilled-water temperature reset from entering-chilled-water temperature for soft load starting at high fluid temperatures.
 3. Proof of chilled water flow before chiller start.
 - a. Differential pressure sensor shall provide proof of flow.
 4. Electric demand limiting through compressor lockout.
 5. Antirecycling timing-out to prevent rapid compressor cycling.
 6. Automatic lead-lag switching.
 7. Automatic cycling of condenser fans through head pressure control.
 8. Start and run during low ambient air temperature to a minimum of 0 degrees F (-18 degrees C).
- D. Automatically reset safety controls: The following conditions shall shut down chiller and chiller shall automatically restart:
1. No chilled-water flow.
 2. Control device failure.
 3. Low voltage or power failure.
- E. Manually reset safety controls: The following conditions shall shut down chiller and require manual reset:
1. Refrigerant low pressure.
 2. Evaporator low temperature.
 3. Refrigerant high pressure.
 4. Low oil flow or pressure.
 5. Compressor motor current-overload protection.
- F. Control system interface: Factory installed connections shall allow the following functions to be displayed or reset through a dry contact or 4-20mA remote signal:
1. Start/stop command.
 2. Chiller alarm status.
 3. Leaving chilled water temperature.
 4. Chilled water setpoint adjustment.
- G. Building management system interface: Factory-installed hardware and software to enable building management system to monitor and control chilled-water setpoint and chiller-control displays and alarms. Interface shall be through a twisted-pair RS-232 connection.

2.29 ELECTRICAL POWER

- A. Power connection: Single-point power connection with unit-mounted lockable, nonfused disconnect for all power except control panel, control panel convenience outlet and evaporator heater.
- B. Three-phase solid-state overload protection for each compressor.
- C. Part-wind or wye-delta starting on all compressors.
- D. Wired grounding lug.
- E. Convenience outlet: 115V GFI female receptacle wired into control circuit.
- F. Separate power connection for evaporator heater.

2.70 CHILLER ACCESSORIES

- A. Chiller sound attenuation: Acoustical compressor blanket insulation and condenser fan panels shall be provided by chiller manufacturer. Additional attenuation as required to meet performance requirements. Sound attenuation shall not de-rate capacity of chiller to below the capacities schedule on the drawings.
 - 1. Performance: Comply with requirements of COMAR Title 26, Subtitle 02, Chapter 03 and maximum 35 dBA within educational spaces.
 - 2. Removable compressor blanket insulation construction:
 - a. 1 or 2 inch thick removable covers.
 - b. Fill: Inert fiberglass needle mat that is mildew resistant, vermin-proof, and incombustible.
 - c. Inner and outer jackets shall be oil and water-resistant of PTFE impregnated fiberglass cloth.
 - d. Raw cut edges shall not be exposed using PTFE cloth binding with PTFE coated fiberglass thread.
 - e. Each section labeled for identification and location.
 - f. Fasteners: Secure covers with 304 stainless-steel hardware and removable straps sewn onto mating flaps.
 - g. Design of covers and fasteners shall withstand vibration, air temperature, equipment temperature not exceeding 450 degrees F (232 degrees C), or humidity with the passage of time.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Provide refrigeration equipment start-up and service by a factory authorized agent during the project correction period as specified in Section 230100.
- B. Chiller shall be mounted on a housekeeping pad and vibration isolators as indicated on the drawings.
- C. Piping connected to the chiller shall be properly supported and designed to permit thermal expansion of piping without undue stress on the piping connections. Each connection shall have valves with unions or flanges so installed that tubes and heads on chiller can be easily removed without draining the entire chilled water system or altering any piping.

- D. Connect refrigerant piping according to Section 232300 "Refrigerant Piping." Connect to suction and liquid tappings with shutoff valve and union or flange at each connection.
- E. Vent relief valves or bursting disks to atmosphere with steel pipe or copper tubing in accordance with ASHRAE 15. Provide insect screen at termination. Provide drip leg and drain valve.
- F. Install chillers level and plumb, and anchor to base.
- G. Install and connect chilled water flow switches.
- H. Insulate evaporator, suction lines, and other surfaces where condensation might occur.
- I. Maintain manufacturer's recommended clearances for service and maintenance.
- J. Electrical wiring: Install electrical components, devices, and accessories furnished loose by manufacturer, including remote flow switches and remote chiller control panel.
- K. Acoustical sound attenuation covers: Install as recommended by manufacturer.

3.60 FIELD QUALITY CONTROL

- A. Manufacturer's field service: Engage a factory-authorized service representative to inspect field-assembled components and chiller installation, including piping and electrical connections. Report results in writing.

3.75 CLEANING

- A. After completing installation, including outlet fittings and devices, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

3.80 SYSTEM STARTUP

- A. Verify that installation complies with the contract documents.
- B. Engage a factory-authorized service representative to perform startup service.
 - 1. Fill out startup checklists and attach copy with contractor startup report.
 - 2. Complete installation and startup checks according to manufacturer's written instructions and check for the following items:
 - a. No physical damage to unit.
 - b. Unit is level.
 - c. Chiller vibration isolation and flexible pipe connections are installed.
 - d. Clearances have been maintained and piping is installed for easy removal for service and tube cleaning.
 - e. Chilled-water pipes have been connected to correct ports.
 - f. Labels and safety instructions are clearly visible.
 - g. Oil levels are as recommended by manufacturer.
 - h. Refrigerant charge is sufficient and chiller has been leak tested.
 - i. Shipping skids, blocks, and straps are removed.
 - j. Refrigerant pressure relief is vented to outside.
 - k. Thermometers and pressure gages are installed.

- l. Controls and safety interlocks are installed and connected.
 - m. Pumps are installed, connected, and operational.
 - n. Check and record performance of chiller protection devices.
- 3. Check and record performance of chilled-water flow and low-temperature interlocks.
 - 4. Operate chiller for run-in period as recommended by manufacturer.
 - 5. Check refrigerant charge. Check oil level.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 230500, provide operating instructions.
- B. Provide at least 8 hours of additional instruction time for the equipment specified in this section, consisting of two periods of four consecutive hours, during a period of not less than 60 days.

END OF SECTION 236419

SECTION 237200 - ENERGY RECOVERY AND DEDICATED OUTDOOR AIR UNITS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Custom-type outdoor-air-handling units with energy recovery.

1.12 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Disconnects for units not provided with factory-installed disconnects: Division 26.

1.14 RELATED SECTIONS

- A. Refrigeration service: Section 230100.
- B. Roof curbs: Section 230506.
- C. Vibration isolation: Section 230548.
- D. Efficiency and power factor of motors: Section 230513.
- E. Variable frequency drive: Section 262923.
- F. Filters: Section 234100.
- G. Controls: Sections 230901 through 230923.

1.20 REFERENCES

- A. ARI 410: Forced-circulation Air-cooling and Air-heating Coils.
- B. ARI 430: Central Station Air-Handling Units.
- C. ARI 1060: Performance Rating Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment.

1.27 PERFORMANCE REQUIREMENTS

- A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted under "Acceptable Manufacturers," below, ascertain that it will:
 - 1. Perform to the scheduled and specified capacities.
 - 2. Make no additional demands on other systems such as domestic, heating, and chilled water, or electricity.
 - 3. Meet or exceed specified requirements.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Shop drawings: Wiring diagrams prepared for this installation, including factory and field wiring of units, accessories, and equipment.

- C. Product data: Each type of unit and each component, including manufacturer's installation instructions.
- D. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing laboratory.
- E. Samples: Provide color samples for selection as required in Part 2.
- F. Certifications: Factory test reports, including test of casing insertion loss performance.
- G. Service agreement specified in "Maintenance Service" below, executed to the Owner and notarized
- H. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space.
 - 1. "Fit in the available space" means that space allows clearances required for service and for overhaul or removal of components.
 - 2. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, including plans, elevations, sections, and diagrams, showing any changes in wiring, arrangement, or access necessary to accommodate the proposed unit.
 - 3. Include shop drawings and product data sufficient to show compliance with the article "Performance Requirements" above.
- I. Shop drawings shall show complete dimensions and configuration of complete assembled unit with accessories, including dimension and configuration, as required to coordinate with framing and bracing roof structure and deck.
- J. Submit fan curves for each unit, with operating points indicated.
- K. Certifications: Fan performance; unit energy performance. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.

1.40 QUALITY ASSURANCE

- A. Unit construction and fan and coil performance shall be certified in accordance with ARI 430 and 410.
- B. UL label and local testing (if required): As specified in Section 230500, Common Work Results for HVAC. Each unit shall be UL listed.
- C. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.
- D. Make fan selections to the right of the peak static pressure point and not on any flat portion of the fan curve. Generally, fan selection shall be in the 50 to 80 percent range of wide open volume.
- E. Provide OSHA-approved fan drive guard where required.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Follow manufacturer's instructions for protecting units during shipping, storage, and handling.

- B. Protect coils and pipe connections with temporary covering until the unit is installed.

1.80 WARRANTY

- A. In addition to general project warranty and correction period, provide manufacturer's special warranties. Compressors shall be warranted for five years, as specified in Section 230100.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Scheduled units are the basis for design of the project. The manufacturers listed also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article "Product Options" in Section 230101, and submit shop drawings and product data as specified in Part 1 above.

1. Munters, Des Champs Technology
2. Engineered Air
3. Innovent
4. Venmar
5. Annexair
6. Xetex

- B. Comply with requirements of Article 1.27 above.

2.10 MATERIALS

- A. Galvanized steel: Hot dipped, ASTM A 123, no less than 0.90 oz. zinc per square foot.
- B. Stainless steel: Type 304.
- C. Insulation: Minimum of R-8 and complying with the requirements of NFPA 90A when installed between metal panels.
 1. Option 1: ASTM 1071, rigid fiberglass, 1.5 lb per cubic foot density, with coated mat facing, meeting the requirements of NFPA 90A.
 2. Option 2: Insulating polyurethane foam injected between interior and exterior panels.

2.21 ENERGY RECOVERY AND DEDICATED OUTDOOR AIR UNITS, GENERAL

- A. Fans and coils shall be removable without dismantling the structural framing.
- B. Weatherproof construction:
 1. Roof sloped no less than 0.25 inch in one foot.
 2. Base adaptable for installation on roof curb.
- C. Base: Welded structural steel channel with integral steel lifting lugs, with manufacturer's standard primer and industrial enamel finish.
- D. Casing: Two-inch double walls, galvanized steel.
 1. Nonloadbearing panels: Exterior 18 gauge and interior 22 gauge.

2. Loadbearing panels: Exterior 16 gauge and interior 18 gauge.
3. Floor: 18 Gauge galvanized steel with sub-floor assembly.
4. Insulation: Walls, floor, and roof, 2 inches thick, completely enclosed in panel construction. Floors shall be insulated to achieve minimum R13. No insulation shall be exposed in the air stream.
5. Access doors: Same construction as walls, insulated, with stainless-steel piano hinges, at least two compression latches, and minimum 24 inches clear opening width.
 - a. Supply and exhaust air streams shall not be accessed via a single door.
 - b. Provide access to filters, fans, heat exchangers, and other areas requiring access for maintenance.
 - c. Gaskets: Automotive style neoprene, full perimeter, preventing air leakage.
 - d. Latches: "Ventlock" style, noncorrosive alloy, operable from the inside and outside of the unit. If access doors do not open against unit operating pressure, provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement.
6. Finish: Interior and exterior galvanized G90. Exterior finished with 1.5-mil industrial enamel or 2-part epoxy primer with urethane modified enamel top coat shown to withstand ASTM B 117 salt spray test for a minimum of 500 hours with no deterioration.
 - a. Provide unit in a factory custom-painted finish with color to be selected by Architect.
7. Drain pans: Sealed, double wall, constructed of minimum 18-gauge galvanized steel exterior and minimum 18-gauge stainless steel interior. Fill space between exterior and interior walls with insulation.
 - a. Slope: Drain pans shall be sloped in 2 planes no less than 0.25 inch in one foot; cross break interior pans and pitch toward drain connections; ensure complete, positive condensate drainage.
 - b. Cooling coils and energy recovery coils shall have drain pans under the entire coil module.
 - c. Connections shall be to the side of the unit and shall enable proper trapping.

2.22 HEAT EXCHANGERS

- A. Counterflow or crossflow flat-plate heat exchangers with performance as scheduled on the drawings, rated in accordance with ARI 1060.
- B. Maximum operating differential pressure: No less than 10 inches wg at 70 degrees F across heat exchanger.
- C. Maximum operating temperature: No less than 400 degrees F.
- D. Construction:
 1. Aluminum frame and 99.5 percent pure aluminum plates no less than 0.008 inch thick.
 2. Entire heat exchanger surface shall be visible for inspection and cleaning without disassembling the heat exchanger.
 3. Drain pans: Under entire heat exchanger, terminated through the side of the unit and properly trapped.

2.23 BLOWER AND MOTOR

- A. Unhoused plenum fans: Airfoil centrifugal type, designed for industrial duty and continuous operation, performance based on testing in accordance with AMCA 210, single-width, single-inlet, Arrangement 4-direct drive fans, sizes and capacities as scheduled on the drawings.
1. Impeller diameters: Comply with the recommendations of AMCA 99.
 2. Blades: Hollow airfoil, double skin welded to the center and wheel-side plates.
 3. Hubs: Cast or welded, with straight bores and keyways, screwed to the shaft with no fewer than two set screws.
 4. Wheels: Statically and dynamically balanced.
 5. Shafts: Solid AISI 1040 or 1045 steel; straight; turned, ground and polished to minimum 16 micro-inch finish; sized to run at a minimum of 20 percent greater fan speed than the maximum in accordance with the AMCA Class.
 6. Bearings: Pillow block, self-aligning, ball or roller type, grease lubricated, minimum L-10 life of 40,000 hours. Both bearings shall be of the same bore, type, and manufacturer; one shall be fixed. Provide lubrication lines extended to the drive side of the fan.
 7. Inlet cones: Steel, formed by spinning; aerodynamically matched to the wheel side plate to provide streamlined air flow to the wheel and fully load the blades; securely attached to the wheel.
 8. Provide discharge safety cages and inlet screens.
- B. Motors: TEFC with NEMA frame and 1.15 service factor, suitable for use with variable frequency drives, complying with requirements of Section 230513.
1. Motor brake hp shall not exceed scheduled values.
 2. Fan brake hp shall not exceed 85 percent of motor brake hp.
- C. Drives: Provide a variable frequency drive (VFD) for each fan, complying with requirement of Section 262923. Mount VFD's in a ventilated unit compartment accessible from the outside of the unit.
1. All units shall be direct driven.
- D. Blower/motor assembly shall be mounted on a unitary base with spring isolators with one inch static deflection.

2.24 DAMPERS

- A. Motorized low-leakage dampers with galvanized steel frame, formed galvanized steel blades, vinyl edge seals, metal jamb seals, and stainless-steel bearings.
1. Outdoor air minimum damper: Airflow measuring, opposed-blade type, modulating actuator (energy recovery units only).
 2. Outdoor air maximum damper: Opposed-blade type, modulating actuator (energy recovery units only).
 3. Return air damper: Opposed-blade type, modulating actuator (energy recovery units only).
 4. Exhaust air minimum/maximum damper: Opposed-blade type, modulating actuator (energy recovery units only).
 5. Recirculation damper: Opposed-blade type, two position actuator.
 6. Exhaust air damper: Opposed-blade type, two position actuator.
 7. Outdoor air damper(s): Opposed-blade type, two position activator.
 8. Traversing defrost control damper.

2.25 HEATING AND COOLING

- A. Heating water coil: ARI 410 rated, drainable, non-trapping, 0.02-inch-wall seamless copper tubes and 0.0075-inch-thick aluminum fins, tested and guaranteed for 250 psi working pressure. Provide an internal pipe chase in the floor of the unit.
- B. Cooling coil: Direct-expansion, ARI 410 rated, 0.02-inch-wall seamless copper tubes and 0.0075-inch-thick aluminum fins, tested and guaranteed for 250 psi working pressure, two circuits, face interlaced, maximum face velocity 500 fpm. Sloped drain pan, coated with bituminous mastic, shall extend under and past the coil. Stub suction line through unit casing (distributor to remain inside unit).
- C. Condensing unit: Integral air-cooled system, factory-piped and -wired, factory-tested and dehydrated and provided fully charged with R-410A. Each air-handling unit shall have a minimum of two independent refrigeration circuits. Condensing unit shall be an integral part of the unit.
 - 1. Compressors: Hermetic scroll type with suction and discharge service valves, reverse rotation protection, sight glass, oil level adjustment, oil filter, rotary dirt trap, nonshort-cycling control, and high and low pressure limits. Minimum one digital scroll or variable speed compressor per unit.
 - 2. Condenser coils: Galvanized casing, seamless copper tubes, and aluminum fins.
 - 3. Condenser fans: Directly driven, with fan guards.

2.26 FILTERS

- A. Air inlet: Provide filter racks for 2-inch deep MERV 8 disposable pre-filters and 4-inch deep MERV 13 final filters.
- B. Exhaust upstream of the heat exchanger: Provide filter rack for two inch deep MERV 8 disposable filters.
- C. Include access doors for side access to filters.
- D. Provide filters as specified in Section 234100.
- E. Filter face areas shall not be less than indicated on the drawings.

2.27 ELECTRICAL SYSTEM

- A. Wiring: Meeting requirements of NEC, unit factory-wired with a single-point power connection. Unit wiring in liquidtight conduit. Entire unit shall be ETL listed, and each major component shall be UL listed.
- B. Provide fused disconnect, fan motor starters with HOA switch and phase loss protection, contactors, control transformer, control circuit fusing, service switch, and terminal block.
- C. Control panel: NEMA 250 Type 3R.
- D. Factory tests shall include test of wiring system.

2.30 SYSTEM CONTROLS

- A. System of factory-provided manufacturer's packaged direct digital temperature controls with electronic actuation, to perform as indicated on the automatic temperature control drawings. Manufacturer's controls shall be provided with BACnet protocol for interface with the DDC system.
- B. Unit manufacturer shall provide devices indicated on the drawings with at least the following features listed below. All devices shall meet the requirements of Sections 230901 through 230923.
 - 1. Supply fan with current sensing relay.
 - 2. Exhaust fan with current sensing relay.
 - 3. Damper actuators.
 - 4. Temperature, humidity, and carbon dioxide sensors.
 - 5. Economizer controls.
 - 6. Modulating hot-gas reheat control.
 - 7. BACnet compatible microprocessor based controls complete with ATC terminal contacts for unit enable/disable, occupied/unoccupied, and general alarm.
 - 8. Control power transformer.
 - 9. Refrigeration cycle controls.
 - 10. Refrigerant safety controls.
- C. ATC contractor shall provide:
 - 1. Field-wiring and -mounting of control instruments as required to accomplish manufacturers packaged sequence of operation.
 - 2. Mounting and wiring of factory-provided devices, including duct smoke detectors, and emergency fan disconnect switch.
 - 3. Signal indicating enable/disable, occupied/unoccupied, and safety/emergency controls.
 - 4. For ERU's only, provide input signal indicating operational mode of two-pipe system (heating or cooling).
- D. Manufacturers packaged controls:
 - 1. Manufacturer provided microprocessor based controller preprogrammed for unit operation, discharge temperature and humidity control, and unit safety control functions. Provide BACnet protocol for non-hard-wire interface (when permitted) with DDC system.
 - 2. Signal to enable/disable unit operation and place the unit into occupied/unoccupied modes of operation shall be provided through hardware interface with DDC system. Provide hardwire contacts for general alarm output to DDC system. For ERU's, provide contacts for receiving two-pipe mode signal (heating or cooling).

2.31 SEQUENCE OF OPERATION – DEDICATED OUTDOOR AIR SYSEMS

- A. General: Unit operation shall be enabled and disabled by respective zone DDC occupied-unoccupied schedule.
- B. Morning warm-up cycle:
 - 1. Unit shall be deenergized throughout the morning warm-up cycle.
- C. Occupied cycle:
 - 1. Recirculation damper shall be proven closed throughout the occupied cycle.

2. OA and EA dampers shall be proven open prior to energizing supply and exhaust fans.
 3. Unit supply and exhaust fans shall be energized and run continuously throughout the occupied cycle.
 4. Traversing defrost shall operate under its packaged controls.
 5. DX cooling coil control:
 - a. OA below 55 degrees F: Compressor operation shall be disabled.
 - b. OA between 55 and 72 degrees F: Compressors shall be staged and cycle to maintain a unit discharge temperature of 72 degrees F, subject to a maximum entering coil dewpoint of 55 degrees F. On a rise in entering coil dewpoint above 55 degrees F, unit shall be placed into dehumidification mode. Compressors shall be staged and cycle to maintain a leaving coil temperature of 55 degrees F during dehumidification. Compressor operation shall be subject to a 50 degree F low-limit leaving coil temperature or a 60 degree F low-limit supply air temperature.
 - c. OA above 72 degrees F: Compressors shall be staged and cycle to maintain a unit discharge temperature of 72 degrees F, subject to a maximum entering coil dewpoint of 55 degrees F. On a rise in entering coil dewpoint above 55 degrees F, unit shall be placed into dehumidification mode. Compressors shall be staged and cycle to maintain a leaving coil temperature of 55 degrees F during dehumidification. Compressor operation shall be subject to a 50 degree F low-limit leaving coil temperature or a 60 degree F low-limit supply air temperature.
 6. Heating coil control:
 - a. OA below 72 degrees F: Heating coil control valve shall modulate to maintain a unit discharge temperature of 72 degrees F.
 - b. OA 72 degrees F and above: Heating coil control valve shall be closed.
- D. Unoccupied cycle:
1. Recirculation damper shall be open throughout the unoccupied cycle.
 2. OA and EA dampers shall be closed throughout the unoccupied cycle.
 3. Unit supply and exhaust fans shall be deenergized and unit shall be placed into the unoccupied mode of operation.
 4. On a rise in space humidity above 60 percent RH, as sensed by the DDC room humidity sensor, unit shall be temporarily energized through a signal from the DDC system and operate in unoccupied dehumidification mode (with bypass damper open, exhaust fan deenergized, and EA/OA dampers closed) to maintain the unit manufacturer's exhaust air humidistat setpoint, located with the unit's exhaust air connection.
 5. Once the space relative humidity falls below 55 percent RH, unit operation shall be deenergized through the DDC system.
- E. Compressor operation:
1. Compressors shall be staged and cycled under the manufacturer's packaged controls to maintain controlling discharge air conditions with the appropriate deadbands and timing intervals to prevent short cycling.
 2. Manufacturer's safeties shall override DDC operations.
 3. Compressor operation shall be disabled when supply fan is off.
- F. Safety and emergency control:
1. Whenever the emergency fan disconnect switch is thrown or limitations are exceeded by any air duct smoke detector, or static pressure sensor, the unit shall be deenergized and OA and

EA dampers shall close. An alarm indicating the specific condition shall be sent to the DDC system.

2.32 ENERGY RECOVERY UNIT SEQUENCE OF OPERATION

- A. General: Unit operation shall be enabled and disabled by respective zone DDC occupied-unoccupied schedule.
- B. Morning warm-up cycle:
 - 1. When indexed to “occupied” by the time schedule and the room temperature is outside the occupied heating/cooling deadband, the optimum start function of the DDC controller shall place the system in morning warm-up mode. The optimum start control function shall provide a space temperature within 1 degree of the occupied setpoint by the occupied time. If adequate space temperature is not achieved by the occupied time, an alarm shall be generated through the DDC system and the unit shall be indexed to the occupied cycle of operation described below.
 - 2. Under the warm-up cycle, the unit supply and return air fans shall be energized and run continuously. OA and EA (both min and max) dampers shall be closed and RA damper shall be open throughout.
 - 3. The heating coil control valve shall modulate to maintain the room temperature sensors occupied heating setpoint.
 - 4. Once the occupied heating temperature setpoint is reached, the unit shall remain in the warm-up cycle (no ventilation) until indexed to the occupied cycle through the DDC system.
- C. Occupied cycle:
 - 1. Supply and return fan operation:
 - a. When the unit is called to operation through the DDC system, the supply fan and return fan shall be energized through their corresponding VFDs and run continuously.
 - b. Supply fan operation (cooling): Modulate between minimum and maximum airflow setpoints to maintain cooling setpoint of the room temperature sensor. Minimum airflow setpoint shall be an adjustable setpoint (factory setpoint: 60-percent of maximum scheduled airflow).
 - c. Supply fan operation (heating): Operate at minimum airflow setpoint, subject to maximum discharge temperature of 85 degrees F. If maximum temperature is exceeded, increase towards maximum airflow setpoint.
 - d. Return fan operation: Modulate fan speed to maintain constant airflow differential with supply fan.
 - 2. Minimum outdoor air control:
 - a. Minimum outdoor air operation shall be enabled when the return air enthalpy is below the outdoor air enthalpy, or the outdoor air temperature is below an adjustable low limit temperature setpoint (factory setpoint: 25 degrees F).
 - b. Minimum outdoor air damper shall open and maximum outdoor air damper shall be closed.
 - c. Return air damper and minimum exhaust air damper shall modulate in opposition to maintain the minimum outdoor air airflow measuring station setpoint. Maximum exhaust air damper shall be closed during minimum outdoor air control.
 - d. Setpoint of minimum outdoor air airflow measuring station shall be incrementally reset between the minimum and maximum setpoints indicated on Energy Recovery Unit Schedule based on room CO₂ level. All setpoints shall be adjustable.

3. Economizer operation:

- a. Economizer operation shall be enabled when the outdoor air temperature is below 60 degrees F and above an adjustable low limit temperature setpoint (factory setpoint: 25 degrees F).
- b. When economizer operation is enabled, minimum outdoor air and exhaust air dampers shall remain open. Maximum outdoor air damper shall modulate to maintain the setpoint of the room temperature sensor, subject to a low-limit mixed air temperature of 50 degrees F.
- c. Return air damper shall modulate in opposition with the maximum outdoor air damper.
- d. Maximum exhaust air damper shall modulate in opposition with the return air damper.

4. Chilled/heating coil operation:

- a. When the two-pipe system is operating in heating mode, chilled/heating coil control valve shall modulate to maintain the room temperature sensors heating setpoint.
- b. When the two-pipe system is operating in cooling mode, chilled/heating coil control valve shall modulate to maintain the room temperature sensors cooling setpoint, subject to a high limit room humidity setpoint of 60 percent RH.
- c. If high limit room humidity setpoint is exceeded, the chilled/heating coil control valve shall modulate to maintain a leaving coil temperature of 55 degrees F.

5. Heat Exchanger-2 and bypass damper operation:

- a. Face and bypass dampers shall be positioned to full bypass around heat exchanger at all times, except within chilled/heating coil is operating in the dehumidification mode.
- b. During dehumidification, face and bypass dampers shall modulate in opposition to maintain the room temperature sensors cooling setpoint.

D. Unoccupied cycle.

1. Unit shall be placed into the unoccupied mode of operation with the outdoor air (both min and max) and exhaust air (both min and max) dampers closed and the return air damper open throughout the unoccupied cycle.
2. Unit supply and return air fans shall cycle and chilled/heating coil control valve shall module to maintain the unoccupied heating and cooling temperature setpoints of the room temperature sensor.

E. Safety and emergency control:

1. Whenever the emergency fan disconnect switch is thrown or limitations are exceeded by any air duct smoke detector or static pressure sensor, the supply fan and return fan shall be deenergized, the outdoor air (both min and max) and exhaust air dampers (both min and max) shall close, and the return air damper shall open. An alarm indicating the specific condition shall be sent to the DDC system.

2.33 ACCESSORIES

A. Provide curbs for roof-mounted units as specified in Section 230506, Curbs and Flashings for HVAC Piping and Equipment.

1. For DOAS-1 and DOAS-2, provide plenum type roof curb (minimum 24-inch plenum curb height).

2.90 SOURCE QUALITY CONTROL

- A. Casing insertion loss: The insertion loss, per octave band, for the casing shall not be less than the following:

Frequency:	<u>63</u>	<u>125</u>	<u>250</u>	<u>500</u>	<u>1000</u>	<u>2000</u>	<u>4000</u>	<u>8000</u>
Insertion loss, dB:	24.8	24.1	22.3	24.7	26.1	29.0	31.2	33.1

Provide verifying test results from lab accredited by the U.S. Dept. of Commerce and the National Institute of Standards and Technology (NIST). Insertion loss verification shall be in accordance with ISO 3746: 1975 Acoustics-survey (comparison) method.

PART 3 - EXECUTION

3.05 PREPARATION

- A. Coordinate installation with the automatic temperature controls subcontractor so that the system and each unit operate in accordance with schedules and sequence of operations.

3.20 INSTALLATION

- A. Install unit in accordance with the manufacturer's instructions and as indicated on drawings.
- B. Install units level and plumb, firmly anchored, in locations indicated and so as to maintain manufacturer's recommended clearances. Provide vibration isolation as specified in Part 2 above and in Section 230548.
- C. Connections: Connect supply and return piping, drains, ducts, and electrical devices in accordance with drawings and manufacturer's instructions. Ground equipment.
- D. Test each drain pan and assure that installed slope is as specified and pan drains completely.
- E. Coordinate with air balancing and provide the proper drive and belts for fan speed to obtain the airflow and static pressure indicated on the drawings.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 230500, provide operating instructions.
- B. Provide at least 4 hours of additional instruction time for the equipment specified in this section.

END OF SECTION 237200

SECTION 237322 - AIR-HANDLING UNITS WITH COILS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Modular air-handling units (AHUs), installed outdoors.

1.14 RELATED SECTIONS

- A. Service and warranty for refrigeration equipment and burners: Section 230100.
- B. Motors: Section 230513.
- C. Power factor correction for motors: Section 230513.
- D. Variable frequency drive: Section 262923.
- E. Filters: Section 234100.

1.20 REFERENCES

- A. ARI 410: Forced-Circulation Air-Cooling and Air-Heating Coils.
- B. ARI 430: Central-Station Air-Handling Units.

1.27 PERFORMANCE REQUIREMENTS

- A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted in the article "Acceptable Manufacturers" below, ascertain that it will:
 - 1. Perform to the scheduled and specified capacities.
 - 2. Make no additional demands on other systems such as domestic, heating, and chilled water, or electricity.
 - 3. Meet or exceed all specified requirements.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data:
 - 1. As required in the article "Quality Assurance" below.
 - 2. For air-handling unit complete with all equipment, options, and accessories, showing compliance with specification.
- C. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space.
 - 1. "Fit in the available space" means that space allows clearances required for service and for overhaul or removal of components.

2. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, including plans, elevations, sections, and diagrams, showing any changes in wiring, arrangement, or access necessary to accommodate the proposed unit.
 3. Include shop drawings and product data sufficient to show compliance with the article "Performance Requirements" above.
- D. Shop drawings shall show complete dimensions and configuration of complete assembled unit with accessories, including dimension and configuration, as required to coordinate with framing and bracing roof structure and deck.
1. Wiring diagrams: Power, signal, and control wiring.
- E. Submit fan curves for each air-handling unit, with operating points indicated.
1. If required in accordance with the article "Quality Assurance" below, submit test results showing the effect on unit capacities.
- F. Certifications: Fan performance; unit energy performance. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.

1.40 QUALITY ASSURANCE

- A. Unit construction and fan and coil performance shall be certified in accordance with ARI 430 and 410.
- B. UL label and local testing (if required): As specified in Section 230500, Common Work Results for HVAC.
- C. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.
- D. Make fan selections to the right of the peak static pressure point and not on any flat portion of the fan curve. Generally, fan selection shall be in the 50 to 80 percent range of wide open volume.
 1. If it should be necessary to provide fan wheels not described in the manufacturer's standard catalog, factory-test the air-handling unit to determine the effect on capacities.
- E. Provide OSHA-approved fan drive guard where required.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide the scheduled units or comparable models of one of the following:
 1. Outdoor units:
 - a. Carrier Corporation.
 - b. McQuay, Daikin Industries.
 - c. Trane Co.
 - d. York, Johnson Controls.

- B. Units mounted outdoors that are not shipped in one piece (with shipping splits dictated by rigging or shipping constraints), and are not manufactured with standing seam design, shall be rigged and assembled under factory-certified site-service supervision. Supervision shall include detailed review of unit assembly and assurance of compliance with manufacturers' installation instructions and written authorized approval at completion of unit installation.

2.10 MATERIALS

- A. Galvanized steel: Hot dipped, ASTM A 123, no less than 0.90 oz. zinc per square foot.
- B. Stainless steel: Type 304.
- C. Insulation: Minimum of R-8 and complying with requirements of NFPA 90A when installed between metal panels.
 - 1. Option 1: ASTM C 1071, rigid fiberglass, 1.5 lb per cubic foot density, with coated mat facing, meeting the requirements of NFPA 90A.
 - 2. Option 2: Insulating polyurethane foam injected between interior and exterior panels.

2.30 AIR-HANDLING UNITS (AHUS)

- A. General: Units shall be modular double-wall construction of the types, module arrangement, and capacities shown and scheduled on the drawings.
- B. Weatherproof construction:
 - 1. Roof sloped no less than 0.25 inch in one foot.
 - 2. Base adaptable for installation on roof curb.
- C. Base: Galvanized steel, minimum 5 inches high, supporting AHU components. Base shall be constructed of wide-flange I-beams or channels, minimum 12-gauge steel. Provide supplemental steel supports as required to obtain proper operation heights for cooling coil condensate drain trap as shown on drawings.
 - 1. AHUs shall be completely self-supporting for installation on concrete housekeeping pad, steel support pedestals, or suspended, as shown on drawings.
- D. Casing (including walls, floor, and roof):
 - 1. Frames: Free-standing, minimum 16-gauge galvanized steel, capable of supporting the weight of the casing and equipment without deflection.
 - 2. Wall panels: Minimum 2 inches thick, double-wall construction, nonload-bearing and removable from exterior. Removing panels shall permit removal of coils and internal components, and cleaning of interior.
 - a. Exterior: Minimum 18-gauge galvanized steel.
 - b. Interior: Galvanized steel, minimum 20 gauge.
 - 3. Sections located upstream of supply fan: Construct for operation at minimum 4 inches wg (1 kPa) negative static pressure.
 - 4. Sections located downstream of supply fan: Construct for operation at minimum 6 inches wg (1.5 kPa) positive static pressure.
 - 5. Joints between casing sections: Seal with closed-cell foam gaskets, water- and air-tight, and providing thermal and acoustical break.

6. Access doors:
 - a. Hinged, removable, designed as specified and as indicated on the drawings.
 - b. Construction: Double wall, same as the unit casing.
 - c. Gaskets: Automotive style neoprene, full perimeter, preventing air leakage.
 - d. Latches: "Ventlock" style, noncorrosive alloy, operable from the inside and outside of unit. If access doors do not open against unit operating pressure, provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement.
 7. Insulation: Insulate casing sections, including access doors and structural framing, completely filling the space between interior and exterior walls. Insulation shall not be exposed to the airstream.
 8. Drain pans: Sealed, double wall, constructed of minimum 18-gauge galvanized steel exterior and minimum 18-gauge stainless steel interior. Fill space between exterior and interior walls with insulation.
 - a. Slope: Drain pans shall be sloped in 2 planes no less than 0.25 inch in one foot; cross break interior pans and pitch toward drain connections; ensure complete, positive condensate drainage.
 - b. Cooling coils and energy recovery coils shall have drain pans under the entire coil module.
 - c. Connections shall be to the side of the unit and shall enable proper trapping.
- E. Coil module:
1. Heavy-duty coil tracks extending the full width of the unit shall hold slip-in coils. Where cooling coils or energy recovery coils are stacked, they shall have intermediate stainless-steel drain pans, with copper drop tubes at each end to drain condensate to the main drain pan without flooding the lower coil.
 2. Coils: Cartridge type, meeting construction and testing standards of ANSI B9.1 Safety Code for Mechanical Refrigeration, performance in accordance with ARI 410. Coils shall be copper tubes with aluminum plate fins and nonferrous headers, no more than 144 fins per foot (305 mm). Fins shall include collars, belled and firmly bonded to the tubes by having the tubes mechanically expanded into the fins.
 3. Water coils: Drainable, with nontrapping circuits and threaded connections for drainage and air venting as well as supply and return connections. Tube wall thickness shall not be less than 0.024 inch (0.6 mm).
- F. Fan module: Fan, motor, and casing panels mounted on steel base. Fan scroll and bearings shall be mounted on an A or H frame structure rigidly secured to the base. Provide access doors on both sides of the module, large enough to permit removal of the fan wheel, motor, and drive.
1. Fan performance: Certified in accordance with ARI 430.
 2. Bearings: Self-aligning, pillow block, regreasable ball types selected for an average life of 200,000 hours at design operating conditions. Bearings shall be provided with grease line extending to the drive side of the fan. Shafts: Steel, turned, ground, and polished.
 3. Fan wheels: Keyed to the shaft and designed for continuous operation at the maximum rated fan speed and motor horsepower. Fans and shafts shall be selected to operate 25 percent below the first critical speed. Fan wheels and shafts shall be statically and dynamically balanced as an assembly. Factory-test the entire unit after final assembly, for vibration. Wheels shall be double-width, double-inlet centrifugal type with backward- inclined airfoil blades unless otherwise noted in schedule. Finish: Zinc-molybdate primer and enamel finish coat.

4. Motors: Open dripproof, 1750 rpm, of current characteristics and horsepower shown on drawings. Motors on suspended units shall be mounted on the catwalk side of unit. Unit motors shall comply with power factor correction requirements of Section 230513.
5. Drive package: Variable pitch for below 30 hp and selected with a service factor of 1.5 based on motor horsepower.
 - a. Guards: Meet OSHA and MOSHA safety requirements.
 - b. Motor shall have adjustable sliding rail bases which permit adjustment of drive belt tension.
 - c. Include one change in drive sheave for each unit if necessary to obtain correct air quantities at time of testing, adjusting, and balancing.
6. Provide a spare matched set of V-belts for drive of each unit.
7. The variable frequency controller shall be a variable frequency drive (VFD) as specified in Section 262923, Variable Frequency Drives. Coordinate to ensure the fan wheel is balanced at all operating speeds. Ensure that unit is free of surge or vibrations due to harmonic frequencies.
8. Vibration isolation: Fan and motor assembly shall be mounted on minimum 16-gauge galvanized steel base and internally isolated from unit casing with spring isolators, furnished and installed by unit manufacturer. Spring isolators shall be 2-inch static deflection with thrust restraints. Fan scroll shall be attached to the unit casing by a flexible canvas duct.

G. Filter module:

1. Include racks for the types of filters indicated. Provide full-height access doors on both sides of module. Provide block-offs as required to prevent air bypass around filters. Provide combination filter/mixing box as scheduled on the drawings.
2. Provide filters as specified in Section 234100.

H. Damper modules:

1. Dampers: Airfoil design, galvanized steel, blades minimum 14 gauge and frames minimum 16 gauge, opposed-blade action with metal compressible jamb seals and extruded vinyl blade edge seals. Blades shall rotate on stainless steel sleeve bearings. Damper blade lengths shall not exceed 60 inches. Leakage rate shall not exceed 8 cfm per sq ft at one inch wg and 12 cfm per sq ft at 4 inches wg.
2. Outdoor air, return air, exhaust air, dampers internally mounted in filter/mixing box and economizer modules as scheduled on drawings.

I. Airflow Monitoring station: Provide a factory-mounted airflow monitor, ASHRAE Standard 62, and control station in the outdoor air opening of the economizer or mixing box module as indicated on the air-handling unit schedule for select units. The monitor shall track the variable outdoor air quantity for ventilation demand flow control and ventilation flow control documentation. The airflow monitoring station shall be factory mounted, calibrated, and installed as recommended by the manufacturer.

1. The air-handling unit economizer module shall include a modulating outdoor air damper, equal to AMS 050 or Ruskin IAQ 50, mounted in series with the airflow monitor.
2. Provide linkages, crank arms, jack shafts, and mounting hardware.
3. Airflow monitoring station shall be calibrated to measure the variable airflow from 15 percent of nominal airflow (air handler cfm) to 100 percent design flow, maintaining an accuracy of plus or minus 5 percent of actual cfm, for air measuring between minus 40 degrees F to plus 158 degrees F. The station shall compensate for outdoor air temperature fluctuations that affect mass flow rate of air.

- J. Access module: Provide access modules as indicated or scheduled on the drawings. Locate access doors on both sides of module, full height and not less than 12 inches wide.

2.80 FABRICATION AND ASSEMBLY

- A. Factory assemble AHUs in accordance with the arrangement shown on the drawings. Units shall be assembled into the largest sections possible subject to shipping and rigging restrictions. On units not shipped fully assembled, the manufacturer shall tag each section and indicate air flow direction to facilitate assembly at the jobsite. Provide lifting lugs or shipping skids for each section to allow for field rigging and final placement of unit. The AHU manufacturer shall provide the necessary materials authorized for assembly.

PART 3 - EXECUTION

3.01 ACCEPTABLE INSTALLER

- A. The manufacturer shall provide a local representative at the job site to supervise the assembly and to assure the units are assembled to meet manufacturer's recommendations and requirements indicated on the drawings.

3.20 INSTALLATION

- A. Assemble and set air-handling units in place as shown on drawings. Provide necessary additional structural members for support from above or below.
- B. Provide duct and piping connections to units in a manner which allows access to removable panels. Piping assemblies shall be arranged to provide full clearance in front of access doors.
- C. Provide connection flanges for ductwork to unit casing in a manner which maintains the structural integrity of the unit and does not interfere with removability of adjacent casing panels.
- D. Assemble and mount humidifier and factory-supplied piping in humidifier module.
- E. Install dielectric pipe nipples at water coil connections where dissimilar metals are joined.
- F. Provide filters in accordance with Section 234100.
- G. Coordinate with air balancing and provide the proper drive and belts or fan speed to obtain the airflow and static pressure indicated on the drawings.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 230500, provide operating instructions.
- B. Provide at least 2 hours of additional instruction time for the equipment specified in this section.

END OF SECTION 237322

SECTION 237413 - PACKAGED ROOFTOP AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Rooftop air-conditioning and heating units, complete with DX cooling and gas-fired heating.

1.14 RELATED SECTIONS

- A. Refrigeration service, warranty, and maintenance: Section 230100.
- B. Supports: Section 230529.
- C. Curbs and flashings: Section 230506.
- D. Sound deadening at roof: Section 230506.
- E. Motors: Section 230513.
- F. Filters: Section 234100.

1.27 PERFORMANCE REQUIREMENTS

- A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted under the article "Acceptable Manufacturers" below, ascertain that it will:
 - 1. Perform to the scheduled and specified capacities.
 - 2. Make no additional demands on other systems such as domestic, heating, and chilled water, or electricity.
 - 3. Meet or exceed all specified requirements.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Shop drawings: Each type of rooftop unit included in the work.
 - 1. Include design of refrigeration piping for remote condensing units prepared by manufacturer of the refrigeration compressor. Show oil traps and accessories specified in Section 232300, Refrigerant Piping, as well as those required by the manufacturer.
 - 2. Wiring diagrams: Power, signal, and control wiring.
- C. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space.
 - 1. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, including plans, elevations, sections, and diagrams, showing any changes in wiring, arrangement, or access necessary to accommodate the proposed unit.
 - 2. Include shop drawings and product data sufficient to show conformance to the article "Performance Requirements" above.

- D. Shop drawings shall show complete dimensions of complete assembled unit with accessories. Include all details necessary for framing supports and openings in roof structure and deck.
- E. Submit fan curves for each air-handling unit, with operating points indicated.
 - 1. If required in accordance with the article "Quality Assurance" below, submit test results showing the effect on unit capacities.
- F. Product data:
 - 1. Rooftop unit and accessories.
 - 2. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
 - 3. Product data shall verify compliance with CEE efficiency requirements.

1.40 QUALITY ASSURANCE

- A. Power factor correction shall be factory-installed as required in Section 230513, Common Motor Requirements for HVAC Equipment.
- B. UL label and local testing (if required): As specified in Section 230500, Common Work Results for HVAC.
- C. Make fan selections to the right of the peak static pressure point and not on any flat portion of the fan curve. Generally, fan selection shall be in the 50 to 80 percent range of wide open volume.
 - 1. If it should be necessary to provide fan wheels not described in the manufacturer's standard catalog, factory test the air-handling unit to determine the effect on capacities.
- D. Regulatory requirements:
 - 1. ICC: HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Units shall be shipped fully charged with refrigerant.
- B. Units that have remote condensing units shall be shipped with holding charge in condensing unit and evaporator.

1.71 COORDINATION

- A. Coordinate installation of roof curbs, equipment supports, and roof penetrations with roof construction. Roof materials and specialties are specified in Division 07 sections.

1.80 WARRANTY

- A. In addition to general project warranty and correction period, provide manufacturer's special warranties.
 - 1. Compressors shall be warranted for five years, as specified in Section 230100.
 - 2. Refrigeration circuits shall be warranted for five years to include the total cost of repairs on labor, parts, and refrigerant. Refer to warranty in Section 230101.
 - 3. Gas-fired heater shall be warranted for ten years.

PART 2 - PRODUCTS

2.30 EQUIPMENT

- A. General: Units shall have vertical air flow off the air-cooled condenser.

2.31 ROOFTOP UNITS

- A. Basis-of-design product: Subject to compliance with requirements, provide the scheduled Aaon RQ unit, or comparable product by one of the following:

1. Aaon, Incorporated
2. Daikin
3. The Trane Company

- B. Performance:

1. Meet scheduled performance requirements and comply with regulatory requirements for efficiency.
2. Do not propose or provide units modified to meet the capacity by providing oversized refrigeration equipment with fewer rows of coil than scheduled, which cannot meet the scheduled efficiency and sensible latent heat ratio.

- C. Unit shall consist of the sections to complete the unit with accessories. Capacity and current characteristics shall be as scheduled on the drawings.

- D. Unit shall be completely factory-assembled, -piped, -wired, and -tested, and shipped in one piece.

1. Units shall be completely factory-assembled with all accessories and sections as indicated on the drawings.
2. Units shall be specifically designed for outdoor rooftop application and shall include a weatherproof cabinet constructed so that rainwater will not stand on top nor collect at any point on the unit.
3. Provide gasketed, hinged doors or panels removable using simple hand tools for access to all parts of the unit requiring service.
4. All sections exposed to return air, mixed air, and supply air shall be insulated with fiberglass of sufficient thickness to prevent condensation during summer operation and which meets NFPA 90A flame-spread and smoke-generation requirements. Insulation shall be securely fastened with adhesive and mechanical fasteners.
5. Cabinet framing and supports shall be of sufficient rigidity for handling without spreader bars.

- E. Cabinet, casing, and frame construction:

1. Unit shall be constructed of steel, hot-dip galvanized after fabrication, or with manufacturer's standard painted finish.
2. Hail guards of galvanized steel, painted to match casing.
3. Decals and tags shall indicate caution areas and aid unit service.
4. Electrical wiring diagrams shall be attached to control panels.
5. Installation and maintenance bulletins shall be supplied with each unit.

- F. Curb:

1. As specified in Section 230506, Curbs and Flashings for HVAC Equipment, curb may be the product of the equipment manufacturer or of a curb manufacturer, provided it meets the requirements of Section 230506.
 2. Provide a curb designed to fit the slope of the roof, full perimeter type.
- G. Compressor: Hermetic or semihermetic, reciprocating, directly driven, 1750 rpm, with isolated mounting, integral suction accumulation, centrifugal oil pump, oil filter screen and magnetic disks, oil-level sight glass, oil-changing valve, lubrication for each bearing connecting rod, crankcase heater and well, suction inlet screen, suction and discharge valves, electrically actuated unloading, replaceable unloader solenoid valves, and suction and discharge valves. Provide suction-gas-cooled motor with voltage utilization range plus or minus 10 percent of nameplate voltages. Two thermostats imbedded between the motor windings shall protect against excessive temperatures. Safety controls shall include high- and low-pressure cutouts, nonrecycling pumpdown, and reset relay.
- H. Evaporator coil: Seamless copper tubing of 0.5-inch OD, mechanically bonded to heavy-duty aluminum fins of manufacturer's standard configuration. Dual circuited coils with independent thermal expansion valves. Factory pressure- and leak-tested at 300 psi.
1. Drain pan: In evaporator section, internally sealed and insulated with copper drain connections.
 - a. Stainless-steel construction.
 - b. Slope to drain in two directions, minimum 0.25 inch in one foot, to 0.75-inch drain connection.
 - c. Provide access for cleaning.
- I. Condenser coil: Aluminum fin in manufacturer's standard configuration, secondary surface mechanically bonded to primary surface of 3/8-inch OD seamless copper tubing. Subcooling circuit(s) with liquid accumulator(s) standard. Factory-tested at 450 psig air pressure.
- J. Unit shall be provided with factory-installed means of disconnect in compliance with NEC and local codes. In the event a factory-installed disconnect is not available as an option, an approved means of disconnect shall be provided for field mounting.
- K. Condenser fans and motors: Vertical-discharge, direct-drive fans, statically and dynamically balanced, with steel blades and zinc-plated steel hubs. Three-phase motors with permanently lubricated ball bearings, built-in current and thermal-overload protection, and weathertight slingers over bearings. Horizontal discharge units not permitted.
- L. Supply and power exhaust fans: Two, double-inlet, forward-curved fans mounted on common shaft with adjustable-sheave drive. All fans statically and dynamically balanced and tested in factory. Run supply fan in unit as part of unit test. Unit shall reach rated rpm before fan shaft passes through first critical speed. Fan shaft mounted on two grease-lubricated ball bearings designed for 200,000 hours average life. Extended grease lines allow greasing of bearings through the filter access door. Fan motor and fan assembly mounted on common base to allow consistent belt tension with no relative motion between fan and motor shafts. Entire assembly completely isolated from unit and fan board by double-deflection, rubber shear isolators on motor sizes larger than five hp.
- M. Filters: Provide filter racks for 2-inch deep MERV 8A pre-filters and 4-inch deep MERV 13A final filters. Provide full height hinged access panels.
1. Provide filters as specified in Section 234100.

- N. Motor efficiency: Provide energy efficient supply and exhaust fan motors as specified in Section 230513, Common Motor Requirements for HVAC Equipment.
- O. Return air: Provide return air arrangement as indicated on drawings.
1. Modulating 100 percent exhaust return fan: Two, double-inlet, forward-curved fans mounted on common shaft with adjustable sheave drive. All fans statically and dynamically balanced and tested in factory. Exhaust fan test run in unit as part of unit test. Unit reaches rated rpm before fan shaft passes through first critical speed. Fan shaft mounted on two grease-lubricated ball bearings designed for 200,000-hour average life. Extended grease lines allow greasing of bearings from unit filter section. Fan motor and assembly mounted on common base to allow consistent belt tension with no relative motion between fan and motor shafts. Entire assembly completely isolated from unit and fan board by double-deflection, rubber-in-shear isolators on motor sizes larger than five hp. Discharge dampers at unit outlet modulate exhaust airflow in response to outdoor air-damper position on constant-volume systems. Units with return air fan and return air, fresh (outdoor) air, and exhaust air motorized modulating dampers are acceptable.
- P. Outdoor air: Provide outdoor-air setup as indicated on drawings.
1. Economizer cycle: Operated through the primary temperature controls to automatically use outdoor air for cooling.
 - a. Automatically modulated return and outdoor air dampers maintain proper temperature into the conditioned space.
 - b. Automatic lockout operates when the outdoor enthalpy temperature is too high for proper cooling.
 - c. Adjustable minimum-position control located on the damper motor.
 - d. Spring return motor ensures closure of outdoor air dampers during unit shutdown or power interruption.
 - e. Mechanical cooling available to aid the economizer cycle at any ambient temperature.
 - f. Mixed-air low limit begins modulating dampers closed at discharge temperature of 62 degrees F. Minimum damper position shall be reached at 50 degrees F discharge temperature.
- Q. Gas-fired heating: Completely assembled and wired gas-fired heating system integral with unit, UL and GSA approved specifically for outdoor applications downstream from refrigerant cooling coils, fire-tested prior to shipment. Provide threaded connection with plug, and gas supply through side or bottom of unit.
1. Heat exchanger: Tubular two-pass design with stainless-steel 16-gauge primary and 18-gauge secondary heat exchanger surfaces, factory pressure- and leak-tested. Design shall prevent stress from expansion, contraction, and associated noise. Provide gasketed cleanout plate for cleaning tubes and turbulators, if required.
 2. Burner: Modulating industrial-type with air-proving switch which prevents operation if burner is open for maintenance or inspection, minimum turndown ratio 10:1, equal to Eclipse "Ratiomatic" RM 100.
 - a. Remote indicating and modulating electronic controller for control of discharge air temperature, equal to Honeywell R7380L.
 3. Combustion blower: Centrifugal-type fan provides air for combustion; fan motor has built-in thermal-overload protection.

- R. Gas-fired heating controls: Manufacturer's packaged controls complying with the unit's UL and GSA listings and compatible with the sequence of operation indicated on the drawings.
- S. Provide a 115-V convenience outlet with its transformer connected to the line side of the power supply, sized to handle a small power load or service light.
- T. Electronic supply-air control: Control components include the equal of Honeywell W7100 discharge-air controller and supply-air sensor. Microprocessor-based W7100 provides precise control of capacity staging, shall contain an adjustable set point for discharge-air temperature, and shall have the ability of indoor air reset and a 2 to 16 degrees F control-band adjustment.
- U. Provide a terminal block with set of terminals to start and stop unit when controlled by automatic temperature control system.

2.32 SYSTEM CONTROLS (SINGLE ZONE VARIABLE-AIR VOLUME)

- A. The ATC contractor shall provide the following:
 - 1. Space temperature, humidity, and carbon dioxide sensors.
 - 2. DDC controllers. DDC controller shall be mounted adjacent to unit manufacturers controller.
 - 3. Switches at each control panel to serve as a panel disconnect. Each panel shall be fuse protected. Comply with Division 26 Section, Low-Voltage Circuit Protective Devices.
- B. The equipment manufacturer shall provide the following:
 - 1. Manufacturers microprocessor based control system, complete with BACnet protocol. System shall provide all temperature and ventilation control functions, including damper, economizer, gas-fired heater, and compressor operations, in addition to refrigeration system control and safeties.
 - a. Provide demand control ventilation minimum outdoor air reset based on room CO₂ levels.
 - b. Provide room pressure exhaust fan control, including room pressure transducer, during economizer.
 - c. Provide interface between unit controller and DDC controller for room temperature and humidity input control functions.
 - 2. Differential pressure switches: Factory-installed switches to indicate fan failure or a blocked filter.
 - 3. Terminal strip for hardwire interface between manufacturers' controls and DDC system, including but not limited to, the following:
 - a. Unit On/Off control functions.
 - b. Occupied/unoccupied control functions.
 - c. General alarm.
 - d. Room temperature input.
 - 4. Provide remote temperature, and carbon dioxide setpoint adjustment through the DDC system.

2.33 SINGLE-ZONE VAV WITH POWER EXHAUST FAN SEQUENCE OF OPERATION

- A. General: Unit operation shall be enabled and disabled by respective zone DDC occupied-unoccupied schedule.

B. Morning warm-up cycle:

1. When indexed to "occupied" by the time schedule, the optimum start function of the DDC controller shall place the system in morning warm-up mode. The optimum start control function shall provide a space temperature within 1 degree of the occupied setpoint by the occupied time. If adequate space temperature is not achieved for all zones by the occupied times, an alarm shall be generated through the DDC system and the unit shall be indexed to the occupied cycle of operation described below.
2. Under the warm-up cycle, the unit supply air fan shall be energized and run continuously as described below for the occupied cycle. OA and EA dampers shall be closed and RA damper shall be open throughout. Power exhaust fan shall be deenergized.
3. Gas-fired heater shall modulate to maintain the room temperature sensors occupied heating setpoint.
4. Once the occupied temperature setpoint is reached, the unit shall remain in the warm-up cycle (no ventilation) until indexed to the occupied cycle through the DDC system.

C. Occupied cycle:

1. Supply fan operation:

- a. When the unit is called to operation through the DDC system, the supply fan shall be energized through its corresponding VFD and run continuously.
- b. Supply fan operation (cooling): Modulate between minimum and maximum airflow setpoints to maintain cooling setpoint of the room temperature sensor. Minimum airflow setpoint shall be an adjustable setpoint (factory setpoint: 60-percent of maximum scheduled airflow).
- c. Supply fan operation (heating): Operate at minimum airflow setpoint.

2. Minimum outdoor air control:

- a. Minimum outdoor air control shall occur at all times, except for economizer operation.
- b. Outdoor air damper shall open to its minimum position.
- c. Return air damper and exhaust air damper (for non-barometric damper units) shall modulate in opposition to maintain the minimum outdoor air airflow measuring station setpoint.
- d. Setpoint of minimum outdoor air airflow measuring station shall be incrementally reset between the minimum and maximum setpoints indicated on Rooftop Unit Schedule. All setpoints shall be adjustable.

3. Economizer operation:

- a. Enable economizer operation when outdoor air dry bulb temperature falls below an adjustable temperature setpoint (factory setpoint: 60 degrees F).
- b. Outdoor air damper shall modulate between its minimum position and wide open to maintain the setpoint of the room temperature sensor, subject to a low-limit mixed air temperature of 50 degrees F.
- c. Return air damper shall modulate in opposition with the outdoor air damper.
- d. Exhaust air damper (for non-barometric damper units) shall modulate in opposition with the return air damper.
- e. Power exhaust fan operation shall be enabled under economizer operation.
- f. Power exhaust fan operation: Modulate to maintain the room pressurization setpoint with respect to the outdoors. Room pressurization setpoint shall be an adjustable setpoint (factory setpoint: +0.05 inch WG room pressurization).

4. DX cooling operation:
 - a. Compressors shall be staged and cycled to maintain the room temperature sensor cooling setpoint.
 - b. Include the appropriate deadbands and timing intervals to prevent short cycling.
 - c. Manufacturer's safeties shall override DDC operations.
 - d. Compressor operation shall be disabled when supply fan is off.
 - e. Gas-fired burner shall be locked out during DX cooling operation.
 5. Gas-fired burner:
 - a. Gas-fired burner shall modulate to maintain the room temperature sensors heating setpoint.
 - b. Manufacturer's safeties shall override DDC operations.
 - c. Burner operation shall be disabled when supply fan is off.
 - d. DX cooling shall be locked out during burner operation.
- D. Unoccupied cycle:
1. Outdoor air and exhaust air dampers shall be closed and the return air damper shall be open throughout the unoccupied cycle.
 2. Power exhaust fan shall deenergized under the unoccupied cycle.
 3. Unit supply fan shall cycle and DX compressors shall be staged, and gas-fired burner shall modulate to maintain the unoccupied heating and cooling temperature setpoints of the room temperature sensor.
- E. Safety and emergency control:
1. Whenever the emergency fan disconnect switch is thrown or limitations are exceeded by any air duct smoke detector or static pressure sensor, the supply fan shall be deenergized, the outdoor air and exhaust air dampers shall close, and the return air damper shall open. An alarm indicating the specific condition shall be sent to the DDC system.

PART 3 - EXECUTION

3.11 SPECIAL REQUIREMENTS

- A. Provide refrigeration and heating equipment startup and service by a factory-authorized agent during the correction period as specified in Section 230100.

3.20 INSTALLATION

- A. Provide a flashing collar where required to make a weatherproof seal. Flashing into the roofing materials shall be as specified in Division 07.
- B. Dielectric pipe fittings shall be installed at water coil connection where dissimilar metals are joined.
- C. Securely attach curb to roof construction as specified in Section 230506, Curbs and Flashings for HVAC Piping and Equipment.
- D. Coordinate with air balancing to provide the proper drive and belts for fan speed to obtain the airflow and static pressure indicated on the drawings.

3.21 SOUND DEADENING FOR ROOFTOP AIR CONDITIONING EQUIPMENT

- A. Install sound deadening materials as specified in Section 230506, Curbs and Flashings for HVAC Piping and Equipment.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 230500, provide operating instructions.
- B. Provide 2 hours of additional instruction time for the equipment specified in this section.

END OF SECTION 237413

SECTION 238127 - DUCTLESS SPLIT-SYSTEM UNITS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Ductless split system with interior and exterior units and refrigerant piping.
- B. Air-conditioning units.
- C. Heat pump units.

1.14 RELATED SECTIONS

- A. Motors: Section 230513.
- B. Piping: Section 232300.
- C. Refrigeration service and compressor warranty: Section 230100.
- D. Filters: Section 234100.
- E. Controls: Sections 230901 through 230923.

1.20 REFERENCES

- A. ASHRAE 15: Safety Code for Mechanical Refrigeration.
- B. ASHRAE 90.1: Energy Efficient Design of New Buildings Except Low-rise Residential Buildings.

1.27 PERFORMANCE REQUIREMENTS

- A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted under the article "Acceptable Manufacturers" below, ascertain that it will:
 - 1. Perform to the scheduled and specified capacities.
 - 2. Make no additional demands on other systems such as domestic, heating, and chilled water, or electricity.
 - 3. Meet or exceed all specified requirements.
 - 4. Electrical power connections for the basis-of-design unit require the indoor unit to be wired through the outdoor unit. Other manufacturers may require separate power connections, which the contractor shall provide as required.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Shop drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring diagrams: For power, signal, and control systems, differentiating between factory- and field-installed wiring.
 - C. Product data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each model.
 1. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
 2. Submit precharged tubing description.
 - D. Samples: Color chips, showing manufacturer's complete line of finishes.
- 1.40 QUALITY ASSURANCE
- A. UL label and local testing (if required): As specified in Section 230500, Common Work Results for HVAC.
 - B. Fabricate and label refrigeration components to comply with ASHRAE 15.
 - C. Energy efficiency ratio and coefficient of performance: Equal to or greater than prescribed by ASHRAE 90.1.
- 1.81 SPECIAL WARRANTY
- A. Besides general project warranty, provide manufacturer's five-year extended warranty for replacing compressors, for each system, executed to the Owner.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide the scheduled Mitsubishi Electric Corporation P Series unit, or comparable product by one of the following:
 1. Daikin AC
 2. Sanyo
 3. Mitsubishi Electric Corporation
 4. Panasonic Air Conditioning Group

2.11 MATERIALS

- A. Refrigerant: HFC 134a.
- B. Refrigerant pipe: Precharged Type L soft drawn, preinsulated seamless copper tubing, ASTM B 280. Length: As short as possible.

2.30 UNITS, GENERAL

- A. Each unit shall be provided with factory-installed means of disconnect in compliance with NEC (NFPA 70) and local codes. In the event a factory-installed disconnect is not available, provide an approved means of disconnect for field mounting.

- B. Heat pump units: Include changeover valves and defrost controls. When heat is called for, the changeover valve reverses the refrigerant flow, the interior coil operates as a condenser, heat is circulated into the room, and the outdoor coil operates as an evaporator.
- C. Air-conditioning units: Interior unit is an air conditioner and the outdoor coil is a condenser.

2.31 INTERIOR UNIT

- A. Frames: Steel angles or aluminum extrusions, welded construction.
- B. Panels:
 - 1. Insulated with 0.5-inch (13-mm) thick, 2 lbs per cubic foot (32 kg per cubic meter) density glass fiber insulation, with an R value no less than 15.
 - 2. Fasteners: Concealed, captive, easily operated for access without tools.
 - 3. Exterior finish: Manufacturer's standard baked enamel.
- C. Grilles: Each one-piece construction, aluminum, brushed finish, with foam gasket providing airtight seal between grille and cabinet. Supply grille adjustable in three directions. Return air grille hinged for access to filter.
- D. Drain pan: Insulated steel or plastic, with connections to exterior of cabinet.
 - 1. Slope to drain in two directions, minimum 0.25 inch in 1 foot, to 0.75-inch drain connection.
 - 2. Provide access for cleaning.
- E. Cooling coil: Aluminum fins extruded on to copper tubing with quick connections to precharged tubing. Pressure tested at 1.5 times working pressure. Provide expansion device.
- F. Fan: Centrifugal type with direct-connected controlled-speed motor mounted on vibration isolators.
- G. Filter: Throwaway type.

2.34 EXTERIOR UNIT

- A. Unit shall be factory-assembled and -tested, of capacity and current characteristics indicated on the drawings. Unit shall be packaged type. Cabinet: weatherproof construction, steel, with baked enamel finish.
- B. Refrigeration circuit: Completely pre-piped, equipped with refrigerant; access valves in suction and liquid lines; filter dryer, sight glass, and pressure fittings for charging and evacuation.
- C. Compressors: Welded shell; reciprocating hermetic, rotary screw or scroll type; high efficiency.
- D. Condenser coil: Constructed of copper tube and aluminum fins, factory leak-tested at 1.5 times working pressure, dehydrated, and provided with full charge of refrigerant. Provide subcooler and accumulator.
 - 1. Low ambient control: Include head pressure control, designed to operate at temperatures down to 0 degrees F (minus 18 degrees C).
- E. Fans: Propeller, direct drive, dynamically balanced, speed-controlled motor.

2.35 CONTROLS

- A. Wall-mounted hard-wired controllers shall incorporate the following features:
 - 1. Operation mode setting (Heat, Auto, Cool)
 - 2. Temperature setting: The LCD indicator displays the set temperature in units of 2 degrees F.
 - 3. Room temperature (intake air) display
 - 4. 24-hour on/off timer: Operation can be set to start or stop after a specified time in 1-hour increments from 1 to 24. The remaining time is indicated on the LCD display.
 - 5. Fan speed indicator: Displays the fan speed setting (high or low).
 - 6. Vane control: The angle of the air outlet vanes can be adjusted to one of four positions by pressing the air discharge Up/Down button.
 - 7. Auto air swing vanes: The air outlet vanes swing up and down for uniform air distribution.
 - 8. Self-diagnostic display: When unit stops, the display indicates where the trouble is located.
 - 9. Memory feature for storing instructions

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Assemble and set each unit in place in accordance with the manufacturer's instructions, plumb and level, firmly anchored, and maintaining manufacturer's recommended clearances.
- B. Connect piping as shown on the drawings and in accordance with manufacturer's instructions.
- C. In a finished space, all piping, wiring, and conduit shall be behind finished surfaces.
- D. Test each drain pan and ensure that installed slope is as specified and pan drains completely.
- E. Install filter provided with unit prior to energizing the unit supply fan.
- F. Prior to final acceptance, remove throwaway filter and install new filter as specified in Section 234100.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 230500, provide operating instructions.

END OF SECTION 238127

SECTION 238128 - VARIABLE-REFRIGERANT-VOLUME MULTIZONE SYSTEM

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Heat recovery type, variable-refrigerant-volume (VRV) system: Distributes refrigerant from the exterior unit to the indoor units to provide simultaneous heating and cooling.
 - 1. Exterior unit: Air cooled.
 - 2. Indoor units: Combination of ceiling mounted cassette type, console units, or fan-coil units.

1.14 RELATED SECTIONS

- A. Motors: Section 230513.
- B. Piping: Section 232300.
- C. Refrigeration service and compressor warranty: Section 230100.
- D. Filters: Section 234100.
- E. Controls: Sections 230901 through 230923.

1.20 REFERENCES

- A. ASHRAE 15: Safety Code for Mechanical Refrigeration.
- B. ASHRAE 90.1: Energy Efficient Design of New Buildings Except Low-rise Residential Buildings.

1.27 PERFORMANCE REQUIREMENTS

- A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted under the article "Acceptable Manufacturers" below, ascertain that it will:
 - 1. Perform to the scheduled and specified capacities.
 - 2. Make no additional demands on other systems such as domestic, heating, and chilled water, or electricity.
 - 3. Meet or exceed all specified requirements.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Shop drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring diagrams: For power, signal, and control systems, differentiating between factory- and field-installed wiring.
- C. Product data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each model.

1. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
2. Submit precharged tubing description.

D. Samples: Color chips, showing manufacturer's complete line of finishes.

1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 230500, Common Work Results for HVAC.
- B. Fabricate and label refrigeration components to comply with ASHRAE 15.
- C. Energy efficiency ratio and coefficient of performance: Equal to or greater than prescribed by ASHRAE 90.1.

1.81 SPECIAL WARRANTY

- A. Besides general project warranty, provide manufacturer's five-year extended warranty for replacing compressors, for each system, executed to the Owner.

1.92 EXTRA MATERIALS

- A. Provide extra washable filter for each ceiling cassette type indoor terminal.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Scheduled units are the basis for design of the project. The manufacturers listed also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 1 and the article "Product Options" in Section 230101, and submit shop drawings and product data as specified in Part 1 above.
 1. Daikin AC
 2. Trane
 3. Mitsubishi Electric Corporation

2.11 MATERIALS

- A. Refrigerant: HFC-410a.
- B. Refrigerant pipe: Refer to Section 232300, Refrigerant Piping.

2.20 UNITS, GENERAL

- A. Each unit shall be provided with factory-installed means of disconnect in compliance with NEC (NFPA 70) and local codes. In the event a factory-installed disconnect is not available, provide an approved means of disconnect for field mounting.

2.21 INTERIOR UNIT

- A. Ceiling cassette fan-coil unit with R-410A refrigerant; equipped with an electronic expansion valve; ceiling cavity type installation with an air panel grille; and capacity as scheduled.
 - 1. Factory assembled to include:
 - a. Expansion valve.
 - b. Control circuit board.
 - c. Fan motor thermal protector.
 - d. Condensate drain pan.
 - e. Condensate drain pump.
 - f. Auto-restart function.
 - g. Fused time delay.
 - h. Test run switch.
 - i. Return air thermistor.
 - 2. Cabinet: Constructed with sound absorbing foamed polystyrene and polyethylene insulation.
 - 3. Fan: Direct drive type with high and low fan speeds.
 - 4. Coil: Copper tubes expanded into aluminum fins to form a mechanical bond.
 - 5. Supply air: 4-way airflow with capability to change to 3-way and 2-way airflow to accommodate various field installations as described on the drawings.
 - 6. Return air: Flow through the concentric panel to include a washable filter as described on the drawings.
 - 7. Shipping: Indoor unit and refrigerant pipes shall be charged with dehydrated air prior to shipment from the factory.
- B. Provide branch selector box at each variable-refrigerant terminal for independent heating and cooling operation.

2.22 EXTERIOR UNIT

- A. Condensing unit: Modular design to allow side-by-side installation with minimum spacing. Factory assembled and pre-wired with all the necessary electronic and refrigerant controls.
 - 1. Safety devices shall include:
 - a. High pressure switch.
 - b. Control circuit fuses.
 - c. Crankcase heater.
 - d. Fusible plug.
 - e. Overload relay.
 - f. Inverter overload protector.
 - g. Thermal protector (overload) for compressor motor.
 - h. Over current protection for the inverter.
 - i. Anti-recycling timer.
 - 2. Cabinet: Corrosion resistant, constructed from rust-proofed, mild steel panels coated with a baked enamel finish.
 - 3. Compressor: Variable speed controlled scroll type compressor(s), capable of changing speeds with variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit.
 - 4. Heat exchanger: Stainless-steel brazed plate type.
 - 5. Features:

- a. Automatic oil recovery cycle.
- b. Automatically restart operation after a power failure without losing programmed settings.
- c. Subcooling feature in circuit: Ensure the liquid refrigerant does not flash when it is being supplied to the various indoor units.

2.23 CONTROLS

- A. The entire system shall be provided with all required controls and shall be designed and installed by the equipment manufacturer.
- B. Each indoor unit shall be provided with a wall-mounted remote controller provided by the unit manufacturer. Controller shall be provided with an LCD display for local adjustment and hard-wired to the associated indoor unit. Controller shall support space temperature setpoint adjustment, provide fan on/off control, display alarm conditions, and permit automatic changeover of heating or cooling operation depending on room setpoint. Room temperature shall be sensed directly at the unit controller and not through the indoor unit's return air path.
- C. Provide a centralized system controller for each outdoor unit for operation of all indoor and outdoor units associated with the system. System controller shall be provided with an LCD display and located as indicated on the drawings. Provide BACnet protocol for interface with the DDC system.

2.24 ACCESSORIES

- A. Filter rack for unit filters.
- B. Provide remote "in-room" sensor kit as described on the drawings.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Assemble and set each unit in place in accordance with the manufacturer's instructions, plumb and level, firmly anchored, and maintaining manufacturer's recommended clearances.
- B. Connect piping as shown on the drawings and in accordance with manufacturer's instructions.
- C. Test each drain pan and ensure that installed slope is as specified and pan drains completely.
- D. Install filter provided with unit prior to energizing the unit supply fan.
- E. Prior to final acceptance, remove throwaway filter and install new filter as specified in Section 234100.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 230500, provide operating instructions.

END OF SECTION 238128

SECTION 238219 - FAN-COIL UNITS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Fan-coil units with water coils for heating and cooling.

1.14 RELATED SECTIONS

- A. Motors: Section 230513.
- B. Filters: Section 234100.
- C. Air-cooled condensing units: Section 236313.
- D. Refrigeration piping: Section 232300.

1.20 REFERENCES

- A. ARI 350: Sound Rating of Non-Ducted Indoor Air-Conditioning Equipment.
- B. ARI 410: Forced-Circulation Air-Cooling and Air-Heating Coils.
- C. ARI 440: Room Fan-Coil Air-Conditioners.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, including plans, elevations, sections, and diagrams, showing any changes in wiring, arrangement, or access necessary to accommodate the proposed unit.
- C. Shop drawings shall show complete dimensions of complete assembled unit with accessories.
- D. Product data: Fan-coil units.
- E. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
- F. Samples: For selection, manufacturer's complete line of colors and textures.

1.40 QUALITY ASSURANCE

- A. Unit capacity shall be certified in compliance with ARI 440.
- B. Unit shall be tested and sound rated in accordance with ARI 350.
- C. UL label and local testing (if required): As specified in Section 230500, Common Work Results for HVAC.

- D. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Ship units with piping capped to prevent entry of foreign matter.
- B. Keep each unit in its carton until installation.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide specified International Environmental units, or comparable units by one of the following:
 - 1. Airtherm Manufacturing Co.
 - 2. American Air Filter
 - 3. Carrier Corp.
 - 4. International Environmental (IEC)
 - 5. McQuay, Daikin Industries
 - 6. Rittling
 - 7. Trane Co.
 - 8. Williams

2.20 FAN-COIL UNITS BASIC REQUIREMENTS

- A. Units shall be type, size, configuration, capacity and current characteristics indicated on the drawings.
- B. Provide each unit with factory-installed means of disconnect in compliance with NFPA 70 (NEC) and applicable local codes. In the event a factory installed disconnect is not available, provide an approved means of disconnect for field mounting.
- C. Exposed parts of cabinet shall be fabricated of 16-gauge (1.6-mm-thick) galvanized steel.
 - 1. Finish:
 - a. Applied to factory-assembled and -tested unit before shipping.
 - b. Bonderize, phosphatize, and coat with baked-on primer with manufacturer's standard enamel, color selected from samples required in Part 1 above.
 - c. Primer and enamel not required for concealed configuration.
- D. Coils as scheduled on drawings.
 - 1. Chilled /heating water coils: Aluminum fins with copper tubes bonded by mechanical expansion, rated for 350 psig (2415 kPa) minimum air pressure and suitable for working pressures up to 250 psig (1725 kPa). Include automatic air vent. Coil performance: as tabulated in the schedule.
 - 2. Direct-expansion coils: Provide with pressure-type brass distributors with solder-type connections. Each coil shall have a distributor providing even distribution of refrigerant with low pressure drop, for each circuit as noted on the drawings, with hot gas injection connections upstream of the distributors. Coils shall be row split and shall have intertwined circuits for equal loading on each circuit. Pressure test coils to 400 psi (2760 kPa), then dehydrate, and charge with dry air. Tubing: copper, minimum 0.5 inch (15 mm) outside

- diameter. Coils shall have suction and discharge connections on the same end. Coil capacity indicated on the drawings shall be certified in accordance with ARI Standard 410. Coil capacity shall balance with the corresponding condensing unit.
- E. Drain pan: For each coil, insulated, no unprotected metal part in contact with water, minimum slope 0.25 inch per foot (20 mm per meter) in two directions, to NPS 0.75 (DN 20) drain connection. See specifications below for additional drain pan requirements.
 - F. Fan assembly:
 - 1. Fans: DWDI forward curved, centrifugal type, directly driven unless otherwise indicated.
 - 2. Housing: Galvanized steel, two-piece construction with removable front half for complete access to fans.
 - G. Motors: Units shall have sleeve bearing motors with oilers, inherent thermal overload protection with automatic reset, and resilient mounts.
 - 1. Either single-speed designed for use with a solid-state variable-speed controller, or three-speed designed for use with a three-speed switch.
 - 2. Split capacitor type at scheduled voltage and complying with requirements of Section 230513.
 - 3. Optional EC(M) motors are acceptable.
 - H. Speed controller: Units shall have an internal unit-mounted and concealed three-speed and off switch, or an internal unit-mounted and concealed solid-state variable-speed controller with integral On-Off switch which provides uniform unlimited fan speed from high to low. It shall include a voltage compensating circuit and RFI filter circuit.
 - I. Cabinet insulation: Provide one type, at least 0.5 inch (13 mm) thick, R value no less than 2.2 (3.8):
 - 1. Glass fiber with foil face: ASTM C 665 and UL 181, with edges exposed to airstream sealed.
 - 2. Elastomeric with erosion-proof face: Closed-cell, exposed faces and edges high density suitable for use in airstreams up to 4500 fpm (22.8 m/s).
 - J. Filters: Include filter rack with one-inch (25-mm) deep disposable flat panel type filters. Larger units require a center filter support so the filter does not sag. Provide filters as specified in Section 234100.

2.22 VERTICAL CONSOLE UNITS

- A. Units meeting the basic requirements specified above and the additional requirements for vertical console configuration.
- B. Equal to International Environmental Corporation model.
 - 1. Flat-top cabinet: FXY.
- C. Combination drain pan and fan deck assembly fabricated of 18 gauge (1.3-mm-thick) galvanized steel and insulated with fire-retardant, closed-cell foam coating. Floor-mounted units shall be provided with an auxiliary drain pan of molded plastic with NPS 0.75 (DN 20) MPT drain connection. Lowboy units shall be provided with a steel, mastic-coated, auxiliary drain pan with NPS 0.75 (DN 20) MPT drain. Auxiliary drain pans shall meet the same slope requirements specified for primary drain pan.

- D. Front panel: Removable.
- E. Grilles:
 - 1. Continuous metal bar discharge grille.
 - 2. Continuous metal inlet grille, screwed to unit casing.
 - 2. Inlet opening in the toe space for return air.
- F. Provide leveling legs on floor-mounted units.
- G. Provide access panels to controls in top of floor exposed units and in the front decorative panel for recessed units.

2.23 VERTICAL CONCEALED UNITS

- A. Units meeting the basic requirements specified above and the additional requirements for vertical concealed configuration.
- B. Equal to International Environmental Corporation model VEY.
- C. Provide duct collar for supply air duct connection on top panel.
- D. Front panel: Removable for access to coils and fan assembly and includes integral filter rack.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Place unit in position and make sure that it is level. Leveling is critical to ensure proper drainage and operation.
- B. Install unit in accordance with the drawings and the manufacturer's instructions.
- C. Provide dielectric pipe nipples at water-coil connections where dissimilar metals are joined.
- D. Coordinate with air balancing to provide the proper drive and belts or adjust fan speed to obtain the air flow and static pressure indicated on the drawings.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 230500, provide operating instructions.
- B. Provide at least 4 hours of additional instruction time for the equipment specified in this section.

END OF SECTION 238219

SECTION 238233 - CONVECTORS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Heating water convectors.

1.14 RELATED SECTIONS

- A. Piping: Section 232113
- B. Controls: Sections 230901 through 230923.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: Convectors.
- C. Samples: Manufacturer's complete line of color chips.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide scheduled Airtherm units, or comparable product by one of the following:
 - 1. Airtherm
 - 2. Dunham-Bush, Inc.
 - 3. Rittling
 - 4. Sterling
 - 5. Trane Company.
 - 6. Vulcan Radiator Corporation.

2.31 CONVECTORS

- A. Convectors shall be recessed, partially recessed, or surface type as indicated on drawings.
- B. Cabinets for recessed and partially (semi-) recessed convectors shall be institutional type having 18-gauge steel backs, ends and tops and 14-gauge steel fronts. Cabinets shall be furnished with grilles for both air inlet and air outlet. The fronts shall be removable for access and shall be secured with flush tamperproof screws. Recessed and semirecessed units shall have overlap trim on all four sides.
- C. Cabinets for surface-mounted convectors shall be institutional type constructed of 14-gauge steel fronts and tops, 16-gauge sides and 18-gauge backs with sloping tops and open bottoms. Front and top shall be constructed with the front panel separate and secured with tamperproof flush screws.

- D. Heating elements shall be suitable for use with a heating water system. They shall consist of 0.5-inch (13-mm) outside diameter round seamless copper tubes, aluminum fins, and 1.25-inch (32-mm) seamless steel headers. Fins shall have flanged collars to space them equally and to provide maximum and permanent contact with the tubes. Tubes shall be hydraulically expanded into the fin collars and brazed to the header with silver solder. The fin and tube assembly shall be encased in a steel frame with intermediate stiffeners. Standard connections shall be top and bottom in one header and top or bottom in the opposite header. Heating elements shall be tested at 250 psi hydrostatic pressure.
- E. Dampers shall be knob type, screw operated for face outlet convectors, and butterfly for sloping top convectors. The knob or key hole shall be located in the top grille of face outlet convectors; on the right hand end of sloping top convectors.
- F. Access doors shall be flush mounted and have slotted head latches. Access door openings shall be reinforced with angle stiffeners. The doors shall be louvered when installed in the inlet or outlet grille.
- G. Convectors where indicated shall have eight-inch end pocket as part of cabinet for use as valve compartment. Provide cam lock access door.
- H. Convectors shall be factory-finished in manufacturer's standard enamel, color to be selected.
- I. Panels shall be sealed with polyurethane gaskets to prevent air leakage.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Coordinate with other trades to assure that recess sizes are correct.
- B. Securely anchor convectors in locations shown. Snugly fit cabinet and trim. Piping connections shall be concealed.
- C. Provide partially recessed or recessed units mounted on exterior walls with 0.5-inch-thick insulation board behind units.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 230500 provide operating instructions.
- B. Provide at least 2 hours of additional instruction time for the equipment specified in this section.

END OF SECTION 238233

SECTION 238238 - ELECTRIC RESISTANCE TERMINAL UNITS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Electrical resistance heating equipment and devices.
- B. Ceiling heaters.

1.14 RELATED SECTIONS

- A. Electric heat tracing: Section 230533.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: Each type and size of heater included in the project.
- C. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
- D. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, plan and sections, showing any changes in wiring, arrangement or access made necessary to accommodate the unit furnished.
- E. Shop drawings shall show dimensions of complete assembled unit with accessories.
- F. Samples: Manufacturer's complete line of colors and textures for cabinets and casings.

1.40 QUALITY ASSURANCE

- A. Each unit, and components as applicable, shall be UL listed and labeled.
 - 1. UL label and local testing (if required): As specified in Section 230500, Common Work Results for HVAC.
- B. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.

PART 2 - PRODUCTS

2.30 ELECTRIC HEATING EQUIPMENT, GENERAL

- A. Capacities and current characteristics of each unit are scheduled on the drawings.
- B. Heaters shall be suitable for voltage characteristics indicated on the drawings.
- C. Provide a factory-mounted electric disconnect switch mounted inside [each] heater.
- D. Provide 24-volt thermostat for remote wall mounting and 24-volt control transformer and contactor to be factory mounted within heater enclosure where remote thermostat is required.

2.39 CEILING FAN HEATERS

- A. Unit shall be 277-volt, single-phase type.
 - 1. Basis-of-design product: Subject to compliance with requirements, provide QMark CDF, or comparable product by one of the following:
 - a. Berko Electric Heating
 - b. General Electric Co.
 - c. Markel Products, Inc.
 - d. Vulcan Radiator Corp.
 - e. QMark
- B. Unit shall be for recessed ceiling or wall mounting with housing constructed of minimum 20 gauge steel. Grille shall be aluminum with louver designed for a downflow pattern.
- C. Electric heating element shall be nickel-chrome with automatically reset thermal overheat protection and controlled by integral snap-action thermostat. Provide hole plug for tamper-resistant thermostat installation.

PART 3 - EXECUTION

3.02 EXAMINATION

- A. Examine roughing-in for electric units to verify actual locations of electrical connections before beginning installation.

3.05 PREPARATION

- A. Coordinate with other trades to ensure that recess or bracing in walls is constructed in locations and with dimensions required for installation of recessed or surface-mounted units.

3.20 INSTALLATION, GENERAL

- A. Install level and plumb.
 - 1. Install manufacturer's access fitting for access to electrical connections, controls, and other fittings.

3.22 INSTALLATION, SUSPENDED UNITS

- A. Suspend unit from construction above or from wall with manufacturer's hanger or 0.5-inch rods in accordance with manufacturers' instructions.
- B. Prevent transmission of vibration to building.

3.30 CONNECTIONS

- A. Ground equipment and connect wiring in accordance with requirements of Division 26.

3.60 FIELD QUALITY CONTROL

- A. Operate electric heating elements through each stage to verify proper operation and electrical connections.

- B. Test and adjust controls including safety controls. Replace damage or malfunctioning controls and equipment.

END OF SECTION 238238

SECTION 238239 - UNIT HEATERS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Unit heaters with water coils.
- B. Cabinet unit heaters.
- C. Propeller unit heaters.

1.14 RELATED SECTIONS

- A. Supports: Section 230529.
- B. Motors: Section 230513.
- C. Electric-resistance unit heaters: Section 238238.
- D. Filters: Section 234100.
- E. Controls: Sections 230901 through 230923.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 230101.
- B. Product data: Each type of heater included in the work.
- C. Samples: Color chips for finish selection, manufacturer's complete line of colors and textures.
- D. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space. Include, if necessary, scale drawings similar to the contract drawings, including plans, elevations, sections, and diagrams, showing any changes in wiring, arrangement, or access necessary to accommodate the proposed unit. Show complete dimensions of complete assembled unit with accessories.
- E. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.

1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 230500, Common Work Results for HVAC.
- B. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.
- C. Components and installation shall comply with NFPA 70 (NEC).
- D. Components and assembled units shall be listed and labeled.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Basis-of-design product: Subject to compliance with requirements, provide the scheduled Airtherm Manufacturing Company units, or comparable product by one of the following:

1. Cabinet unit heaters:
 - a. Airtherm Manufacturing Company
 - b. American Air Filter
 - c. McQuay, Daikin Industries
 - d. Rittling
 - e. Sterling
 - f. Trane Company
 - g. Vulcan Radiator Corporation
2. Propeller unit heaters:
 - a. Airtherm Manufacturing Company
 - b. American Air Filter
 - c. Dunham-Bush, Inc.
 - d. McQuay, Daikin Industries
 - e. Rittling
 - f. Sterling
 - g. Trane Company
 - h. Vulcan Radiator Corporation

2.31 CABINET UNIT HEATER

- A. Arrangement, capacities, and current characteristics are indicated on the drawings.
- B. Unit shall be complete with fan, motor, heating element, and cabinet with inlet and outlet grilles.
- C. Cabinet: Steel, 16-gauge with 18-gauge top and sides, phosphatized and finished with baked enamel in a color to be selected.
 1. Cabinet front shall be removable for access to motor, fans, heating element and appurtenances.
 2. Vertical cabinet shall be without openings in top, bottom, sides, and back.
 3. Cabinet front for recessed and semi-recessed units shall have overlap trim on all four sides.
- D. Fan: Forward-curved, double-inlet type, designed for quiet operation, directly driven.
- E. Heating element: Constructed of copper tubes with non-ferrous fins.
- F. Motor: Resiliently mounted, three-speed, tap-wound with built-in overload protection, suitable for operation on 115-V, single phase, 60-cycle current, permanent split-capacitor type. Generally, capacities are to be selected at medium or low speed. Motors shall comply with requirements of Section 23 0513.
- G. Unit controls: Unit-mounted fan-speed switch and wall-mounting, 24-volt thermostat.

- H. Each unit shall have a filter rack to accommodate at least a 1/2-inch-thick filter, arranged to provide at least one sq. ft. of filter medium surface for each 300 cfm air delivery. Provide throwaway filter with each unit.
- I. Provide each unit with factory-installed means of disconnect in compliance with NFPA 70 (NEC) and applicable local codes. In the event a factory installed disconnect is not available, provide an approved means of disconnect for field mounting.

2.32 PROPELLER UNIT HEATER

- A. Type, capacity, and current characteristics are indicated on the drawings.
- B. Casing: Steel, phosphatized and finished with baked enamel.
 - 1. Horizontal units: Furnished with double-deflection louver to allow for horizontal and vertical deflection of air pattern.
 - 2. Vertical units: Diffuser shall provide widespread discharge air pattern.
- C. Heating element: Copper or copper alloy tube, welded or brazed. Extended surfaces shall be aluminum plate fins with tube expanded into collar.
- D. Fan: Directly connected to single-speed electric motor and provided with wire guard. Motors shall comply with requirements of Section 230513.

PART 3 - EXECUTION

3.05 PREPARATION

- A. Coordinate with work of other trades to ensure that substrates and supports, and openings for recessed and semi-recessed unit heaters, meet requirements for installation tolerances and other conditions.

3.20 INSTALLATION, GENERAL

- A. Install unit as shown on drawings, according to manufacturer's instructions, and in accordance with NFPA 90A.
- B. Set each unit plumb and level and ensure that coils drain properly.
- C. Install securely fastened in place.

3.21 INSTALLING CABINET UNIT HEATERS

- A. Recessed and semi-recessed heaters:
 - 1. Install eight inches or one block course above floor unless otherwise shown on the drawings.
 - 2. On exterior walls, provide 0.5-inch rigid fiberglass insulation behind the heater.
- B. Surface-mounted heaters:
 - 1. Install at least four inches above floor.
 - 2. Secure to wall with no fewer than four bolts.
- C. Install piping and electrical connections concealed.

D. Filters:

1. Install throwaway filter provided with unit before energizing the unit fan.
2. Before air balancing, remove throwaway filter and install disposable, medium-efficiency filter specified in Section 234100, Particulate Air Filtration.

E. Ensure that all components are accessible when front panel is open.

3.22 INSTALLING PROPELLER UNIT HEATERS

- A. Suspend from structure above with hanger rods not less than 0.5 inch in diameter.
- B. Install in a manner and, if necessary, with vibration control devices so that vibration is not transmitted to the structure.

3.70 ADJUSTING

- A. For cabinet unit heaters, coordinate with air balancing subcontractor to adjust fan speed to obtain the airflow and static pressure shown on the drawings. If necessary, provide belts, sheaves, or other parts required to complete balancing.

END OF SECTION 238239

SECTION 260101 - ELECTRICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. General provisions and requirements for electrical work.

1.14 RELATED SECTIONS

- A. Requirements of this section generally supplement requirements of Division 01.
- B. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.

1.20 REFERENCES

- A. NFPA 10: Portable Fire Extinguishers.
- B. NFPA 241: Safeguarding Construction, Alteration, and Demolition Operations.

1.24 SYSTEM DESCRIPTION

- A. The full set of Contract Documents applies to work of Division 26.
- B. Visit the site and study all aspects of the project and working conditions, as required by General and Supplementary Conditions, Bidding and Contracting Requirements, Drawings, and Specifications. Verify field dimensions.
- C. The work covered in technical sections includes the furnishing of all labor, equipment and materials, and the performance of all operations pertinent to the work described.
- D. Except as required otherwise in Division 01, promptly obtain and pay for, all necessary signatures and paperwork, all permits, fees and inspections required for work of this division by authorities having jurisdiction, including any utility connection or extension charge. No payment will be made until a copy of the permit is forwarded to the Owner.
- E. Electrical work of this project includes, as a brief general description, the following:
 - 1. Power distribution.
 - 2. Lighting/lighting controls.
 - 3. Wiring devices.
 - 4. The project includes commissioning under the direction of a Commissioning Agent (CxA).
 - 5. The project will be LEED certified.
- F. See Division 01 for requirements related to LEED certification, commissioning, limits on use of site, time restrictions on work, limits on utility outages or shutdowns, and phasing (sequencing) and scheduling.

1.26 PRODUCT OPTIONS

- A. Except as modified by provisions of Bidding and Contracting Requirements and Division 01, these options apply to Division 26 specifications.

- B. General: Where Contractor is permitted to use a product other than the specified item and model named as the basis of design, Contractor is responsible for all coordination and additional costs as specified in article "Substitutions" below for substitutions.
- C. Products specified by reference standards or by description only: Any product meeting those standards or description.
- D. Products specified by naming one or more manufacturers, or model name or catalog reference number: Products specified establish a standard of quality, options to be included, and performance.
 - 1. Where other acceptable manufacturers are named, Contractor may provide products of those named manufacturers only, which meet the specifications.
 - 2. Where specification permits "equal" products, without naming other acceptable manufacturers, Contractor may use products of any manufacturer, which meet the specifications.
- E. Products specified by naming one manufacturer and particular product, with no provision for other options: No options or substitutions allowed.

1.27 SUBSTITUTIONS

- A. Substitutions will be considered only as permitted or required by the Bidding and Contracting Requirements and Division 01. Except as modified by those requirements, the requirements below apply to Division 26 specifications.
- B. Substitutions may be considered when a product becomes unavailable through no fault of the Contractor.
- C. Document each request with complete data substantiating compliance of proposed substitution with contract documents.
- D. A request constitutes a representation that the Bidder or Contractor:
 - 1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product.
 - 2. Will provide the same warranty for the substitution as for the specified product.
 - 3. Will coordinate installation and make changes to other work which may be required for the work to be complete with no additional cost to Owner.
 - 4. Waives claims for additional costs or time extension which may subsequently become apparent.
 - 5. Will reimburse Owner for review or redesign services associated with re-approval by authorities.
- E. Substitutions will not be considered when they are indicated or implied on shop drawing or product data submittals, without separate written request, or when acceptance will require revision to the Contract Documents.
- F. Substitution submittal procedure is specified in Bidding and Contracting Requirements and Division 01.

1.28 MATERIALS AND EQUIPMENT

- A. All materials and equipment shall be new and the best of their respective kinds, suitable for the conditions and duties imposed on them by the project, and of representative manufacturer. The description, characteristics and requirements of the materials to be used shall be in accordance with the specifications.
- B. All equipment, construction and installation must meet requirements of local, state and federal governing codes.
- C. Singular number: In cases where material, a device, or part of the equipment is referred to in the singular number in the specifications, it is intended that such reference shall apply to as many items of material, devices, or parts of the equipment as are required to complete the installation as shown on the drawings or required for proper operation of the system.
- D. Terms have the following meanings:
 - 1. Furnish: Supply item
 - 2. Install: Mount and connect item
 - 3. Provide: Furnish and install
- E. All materials and equipment shall be installed and completed in a first class and workmanlike manner and in accordance with the best modern methods, practice and manufacturers' instructions. Any work which shall not present an orderly and neat or workmanlike appearance shall be removed and replaced with satisfactory work when so directed in writing by the Architect.
- F. The specifications and drawings are intended to define the minimum requirements, as to quality of materials, construction, finish and overall workmanship.
- G. General Conditions describe the correlation and intent of the Contract Documents. In case of discrepancies between the specifications and drawings, the specifications should be followed as to the general methods and principles and the drawings followed as to sizes, capacities and specifics for corresponding parts. If sizes are omitted, the Architect will determine sizes to be utilized.
- H. In all cases of doubt, uncertainty, or conflict as to the true meaning of the specifications or drawings, it is the responsibility of the Contractor to notify the Architect of said uncertainty, doubt, or conflict and obtain a decision as to the intent prior to initiating any work which may be affected by this decision.

1.29 COORDINATION

- A. Should a situation develop during construction to prevent the proper installation of any equipment or item where shown on the drawings, call the situation to the attention of the Architect and await a written decision.
- B. Plan and coordinate all work to proceed in an orderly and continuous manner without undue delay, and in conformance with the project schedule. Submit samples, shop drawings, schedules, insurance policies and certificates, and the like in time to avoid delays in actual construction. Coordinate electrical work so that work of each trade is completed before other construction begins which would obstruct it.
- C. Coordinate trades to ensure that proper clearances between work of the various trades allow access to items which require operation and maintenance.

- D. Coordinate location and elevation of all conduit, light fixtures, equipment, and appurtenances in such a manner that the finished installation is as indicated on drawings. In the event difficulties are encountered which prevent this, it is the Contractor's responsibility to bring this to the attention of the Architect prior to initiation of work. Correct improperly coordinated installation at no additional cost.
- E. The Contractors' assistants shall include a competent electrical foreman, who shall be on the premises at all times to check, layout, coordinate and superintend the installation of work. The foreman shall establish all basic requirements relative to the work before starting, and be responsible for the accuracy thereof.

1.30 SUBMITTALS

A. Manufacturers' and subcontractors' lists:

- 1. As specified in Division 01, submit a complete list of proposed manufacturers for all equipment, materials and subcontractors used for the work of this division. Lists shall follow the sequence of the specifications. No considerations will be given for partial or incomplete lists. After review of lists, submit shop drawings and product data.

B. Shop drawings and product data:

- 1. Submit in accordance with the requirements of Division 01 or as established at the preconstruction conference, the required number of copies of Shop Drawings and Product Data for every item of equipment. Shop drawings or product data will not be considered until Manufacturers' Lists have been approved. Shop drawings and product data shall be submitted, as required by the General Conditions, with sufficient time for checking, return to Contractor, and resubmission as required before Contractor shall install any item.
- 2. Each item submitted shall be properly labeled, indicating the specific service for which the equipment or material is to be used, section and paragraph number of specification or drawing number to which it applies, Contractor's name and project name and number. Data submitted shall be specific and shall include product data and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents. Clearly identify each item within the data. Data of a general nature will not be accepted. Each sheet must clearly show the project name and number.
- 3. The review of a shop drawing or product data shall not be considered as a guarantee of the measurements or building conditions or that the shop drawings or product data have been checked to see that item submitted properly fits the building conditions. This review shall not relieve the Contractor of the responsibility for furnishing material or performing work as required by the contract documents, for correctness of dimensions and quantities, or for proper coordination of details and interfaces among trades.
- 4. All exclusively electrical items furnished as items associated with mechanical items but not specifically described in the mechanical item submission, shall be submitted as a separate submittal but shall be clearly marked as associated with the mechanical item by identified specification paragraph.
- 5. Product data sheets shall be 8.5-inches by 11-inches cut sheets for operating and maintenance manual.

C. Submit at least three copies of the results of every test required under any section in this division.

- D. Specialist shall submit a list of at least three projects similar to this project in type, size, and quality, which have been in place and operating satisfactorily for at least five years.

1. Include project name, address, name and phone number of owner's representative, and project type and size.

E. After the work is completed, submit all required certificates of approval from approved inspection agencies and authorities having jurisdiction over work of this division. Certificates of approval must be received by the Architect prior to final acceptance of the work.

1.34 SPECIALIST

A. The term "Specialist" as used in the specification shall mean an individual or firm of established reputation (or, if newly organized, whose personnel have previously established a reputation in the same field,) which is regularly engaged in, and which maintains a regular force of workers skilled in either (as applicable) manufacturing or fabricating items required by the contract, installing items required by the contract, or otherwise performing work required by the contract. Where the specification requires installation by a specialist, the term shall also be deemed to mean the manufacturer of the item, an individual or firm licensed by the manufacturer, or an individual or firm who will perform the work under the manufacturer's direct supervision.

1.35 CONTRACT CLOSEOUT SUBMITTALS

A. Project record documents:

1. Maintain on site one set of the following record documents; record actual revisions to the work of this division:

- a. Contract Drawings.
- b. Specifications.
- c. Addenda.
- d. Change Orders and other Modifications to the Contract.
- e. Reviewed shop drawings, product data, and samples.

2. Maintain record documents separate from documents used for construction.

3. Record information concurrent with construction progress.

4. Specifications: Legibly mark and record in each section a description of actual products installed, including the following:

- a. Manufacturer's name and product model and number.
- b. Product options, substitutions, or alternates utilized.
- c. Changes made by addenda and modifications.

5. Record documents and shop drawings: Legibly mark each item to record actual construction, including:

- a. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
- b. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the work.
- c. Field changes of dimension and detail.
- d. Details not on original Contract Drawings.

6. Submit documents as specified in Division 01.

B. Operation and maintenance data:

1. Submit sets prior to final inspection as specified in Division 01. Unless otherwise specified in Division 01, submit no fewer than three sets. In addition to requirements specified in Division 01, submit operating and maintenance manuals for the work of this division as specified below.
2. Binders: Provide large enough binders, and sufficient quantity, that the required contents can be easily turned, removed, and reinserted.
 - a. Self-expanding fast lock type.
 - b. Three telescoping metal posts.
 - c. Durable plastic covers.
 - d. Angle spline with guide flanges.
 - e. Text page size - 8.5 by 11 inches.
 - f. Boorum and Pease, Stock No. C-619-3 expansion 3 inch to 5 inch or Stock No. C-1219 expansion 1.5 inch to 2.5 inch, or equal by National or Wilson Jones.
3. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS," and title of project. Print on spine of binder "O & M INSTRUCTIONS." If more than one binder is required, print covers and spines with volume numbers. Include in the front of every binder an index to all binders.
4. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.
5. Contents: Prepare a Table of Contents for each volume, with each product or system description identified, typed on white paper.
6. Part 1: Directory, listing names, addresses, and telephone numbers of electrical engineers; contractor; electrical subcontractors; and major electrical equipment suppliers.
7. Part 2: Operation and maintenance instructions, arranged by specification section. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers. Identify the following:
 - a. Significant design criteria.
 - b. List of equipment.
 - c. Parts list for each component, including recommended spare parts list.
 - d. Operating instructions.
 - e. Maintenance instructions for equipment and systems.
 - f. Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.
8. Part 3: Project documents and certificates, including the following:
 - a. Shop drawings and product data.
 - b. Photocopies of certificates.
 - c. Photocopies of warranties, guarantees, and bonds.
 - d. Test reports: Copies of the results of all tests required under all sections of specifications.
 - e. Photocopies of each panelboard circuit directory or directories for each panelboard provided, including panel name, panel location, panel ratings, spare circuit breakers and spaces for additional circuit breakers.
9. Submit one copy of completed volumes in final form 15 days prior to final inspection. This copy will be returned after final inspection, with Engineer comments. Revise content of documents as required prior to final submittal.
10. Submit final volumes revised, within ten days after final inspection.
11. Submit DVD optical disc storage media specified in Section 260500.

1.42 REGULATORY REQUIREMENTS

- A. When these specifications call for materials or construction of a better quality or larger sizes than required by the following codes and standards, the provisions of the specifications shall take precedence.
- B. Provide, without extra charge, any additional materials and labor which may be required for compliance with these codes and standards even though the work is not mentioned in these specifications or shown on the contract drawings.
- C. Perform the work of this division in strict accordance with the following authorities. The latest revision of these codes accepted by the authority having jurisdiction as of the date of the contract documents shall apply.
 - 1. The electrical, building, fire, and safety codes of the state and county or city in which the work is being performed.
 - 2. The National Electric Code, NFPA 70 (NEC).
 - 3. The National Fire Protection Association Code. (NFPA)
 - 4. International Building Code (IBC).
 - 5. International Energy Conservation, Fire, and Electrical Codes (ICC).

1.43 REFERENCE STANDARDS

- A. Perform the work of this division using the standards of the following organizations, as referred to in technical sections, as a minimum requirement for construction and testing. Unless specified otherwise in Bidding and Contract Documents or Division 01, the latest revision current as of the date of the contract documents shall apply.
 - 1. Factory Mutual (FM)
 - 2. Federal Specifications (FS)
 - 3. Military Standards (Mil. Std.)
 - 4. American National Standards Institute (ANSI)
 - 5. American Society for Testing and Materials (ASTM)
 - 6. International Code Council (ICC)
 - 7. Institute of Electrical and Electronics Engineers (IEEE)
 - 8. National Electrical Code (NEC) (NFPA 70)
 - 9. National Electrical Manufacturer's Association (NEMA)
 - 10. National Fire Protection Association (NFPA)
 - 11. The Occupational Safety and Health Act (OSHA)
 - 12. Underwriters Laboratory Inc. (UL)
 - 13. American Association of State Highway and Transportation Officials (AASHTO)
 - 14. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)
 - 15. Maryland Occupational Safety and Health Act (MOSHA)
 - 16. Illuminating Engineering Society of North America (IESNA)

1.53 TEMPORARY STORAGE

- A. Maintain upon premises, where directed, a storage area, and be responsible for all contents within these areas. Provide all security measures necessary for this area.
- B. Area shall be maintained and shall be returned to original condition at the completion of the project.

- C. Store electrical construction materials such as wire, raceways and boxes, devices, and equipment in buildings, enclosed trailers, or portable enclosed warehouses.
 - 1. Materials and products subject to damage from moisture: Store in dry locations. If necessary, protect with protective wraps or covers.
 - 2. Plastics and other materials and products subject to damage from heat or cold: Store at manufacturer's recommended temperatures.
 - 3. Plastics and other materials and products subject to damage from sunlight: Protect from sunlight.
- D. Electrical equipment such as motor controllers, panelboards and circuit breakers stored before installation and installed during construction: Provide clean, dry locations at manufacturer's recommended temperatures, and cover or wrap if required to protect from incidental damage.

1.54 PROTECTION

- A. Each trade and subcontractor is responsible for preventing damage and soiling of work performed by other trades or subcontractors. Each trade and subcontractor is responsible for providing temporary protection of its own work.
 - 1. Protect work from spills, splatters, drippings, adhesives, bitumens, mortars, paints, plasters, and damage from welding or burning.
 - 2. Protect finished work from damage, defacement, staining, or scratching.
 - 3. Protect finishes from cleaning agents, or grinding and finishing equipment.
 - 4. Protect adjacent and finished work from damage, using tape, masking, covers or coatings and protective enclosures.
 - 5. Coordinate installations and temporarily remove items to avoid damage from finishing work.
- B. Repair all damage or soiling to the complete satisfaction of the Architect; replace any materials or work damaged to such an extent that they cannot be restored to their original condition, all at no addition to the Contract sum.
- C. Protect work stored in place and supplies stored in the building.
 - 1. Store materials and products, subject to damage from moisture, in dry locations. If necessary, protect in wraps or covers.
 - 2. Store plastics, other materials, and products subject to damage from heat or cold at manufacturer's recommended temperatures.
- D. Protect electrical materials and products from weather events and accidents of construction.
- E. Use of sidewalk or roadway areas outside of the property lines shall be with permission and approval of the local authorities having jurisdiction.

1.55 FIRE PROTECTION

- A. As a minimum, provide hand-carried, portable, UL-rated extinguishers with each work crew working inside the building.
- B. Select extinguishers in accordance with NFPA 10 and NFPA 241 for classification, extinguishing agent, and size required by location and class of fire exposure.

1.60 PROJECT CONDITIONS

- A. Drawings showing utilities in concealed locations are based on the best information available but are not represented as being precisely correct. Work of the contract includes digging, cutting, drilling, using nondestructive methods, and other methods of locating concealed utilities in the field, as well as patching and repairing as specified in "Cutting and Patching" below.
- B. If, in the course of the work, workers encounter a material they suspect to present some hazard:
 - 1. Promptly notify the Architect in writing.
 - 2. Do not perform any work which would disturb the suspected material until written instructions have been received.

1.80 WARRANTY

- A. All work and equipment provided as work of this division shall be fully warranted under the general project warranty. In addition, provide added special warranties as specified in individual sections.
- B. During the correction period, the Contractor shall promptly correct any work found to be defective or otherwise not in accordance with the requirements of the Contract Documents, on receipt of written notice from the Owner. Except as otherwise required in General Conditions and Division 01, the correction period is two years after the date of substantial completion of the work. Work requiring correction shall promptly be repaired or completely replaced at no addition to the Contract Sum.
- C. When use of the permanent equipment has been permitted for temporary services during construction of the building, the warranty and correction periods shall nevertheless begin at the time of substantial completion, unless another date of acceptance has been agreed to by the Owner.
- D. Special warranties are warranties required by individual specification sections, incidental product warranties, manufacturers' standard warranties, installer or subcontractor service agreements, and other individual warranties in addition to the general project warranty.
- E. Provide copies of warranties as required for Operation and Maintenance Manual specified above, and by Division 01.
- F. For items of work delayed beyond date of substantial completion, provide updated submittal within ten days after acceptance, listing date of acceptance as start of warranty period.

1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.11 CUTTING AND PATCHING

- A. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
- B. Cut walls, floors, partitions, roofs, and other appurtenances for the passage or accommodation of conduits. Close superfluous openings and remove all debris caused by work of this division.
- C. No cutting of any structure or finish shall be done until the condition requiring such cutting has been examined and approved by the Architect.
- D. New or existing surfaces disturbed as a result of such cutting or otherwise damaged shall be restored to match original work and all materials used for any patching or mending shall conform to the class of materials originally installed.
- E. Refinish surfaces to match adjacent finish. For continuous surfaces, refinish to nearest intersection or natural break. For an assembly, refinish entire unit.

3.14 TEMPORARY FACILITIES

- A. Temporary water facilities, electricity, telephone, toilet facilities, and temporary heat, shall be provided as specified in Division 01.

3.40 PROGRESS MEETINGS

- A. Progress meetings shall be held as specified in Division 01, and also when and if the Contractor or Architect finds them necessary or advantageous to progress of work.
- B. Contractor, those subcontractors and those material suppliers concerned with current progress or with the scheduling of future progress, Architect and Owner shall each be represented at these meetings by persons familiar with the details of work and authorized to conclude matters relating to work progress.

3.82 COMMISSIONING

- A. Comply with requirements of 'Commissioning' in Part 1 above.

END OF SECTION 260101

SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Requirements applicable to work of more than one section of Division 26.
- B. Testing wiring systems.

1.14 RELATED SECTIONS

- A. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.
- B. Operation and Maintenance Manuals: Division 01 and Section 260101.
- C. Painting: Division 09.

1.21 DEFINITIONS

- A. Project correction period: A period after Substantial Completion of the work during which the Contractor shall correct every part of the work found to be not in accordance with the requirements of the contract documents, promptly after receipt of written notice.
- B. Qualified testing agency: A Nationally Recognized Testing Laboratory (NRTL), a National Voluntary Laboratory Accreditation Program (NVLAP), or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ASTM E 548; and with additional qualifications specified in individual sections; and where required by authorities having jurisdiction, that is acceptable to authorities.

1.26 DESIGN REQUIREMENTS

- A. The drawings and system performances have been designed on the basis of using the particular manufacturers' products specified and scheduled on the drawings.
- B. Products of other manufacturers that are listed under the article "Acceptable Manufacturers," or permitted as "equal," are permitted provided:
 - 1. Product shall meet the specifications.
 - 2. Contractor shall make, without addition to the contract sum, all adjustments for deviations so that the final installation is complete and functions as the design basis product is intended.
- C. Do not propose products with dimensions or other characteristics different from the design basis product that make their use impractical or cause functional fit, access, or connection problems.
- D. The contract drawings are generally diagrammatic, and do not indicate all fittings or offsets in conduit or all pull boxes, access panels, or other specialties required.
 - 1. Install conduit exposed to view parallel with the lines of the building and as close to walls, columns, and ceilings as may be practical, maintaining adequate clearance for access at parts requiring servicing.
 - 2. Install conduit a sufficient distance from other work to permit a clearance of not less than 0.5 inch (15 mm) between its finished covering and adjacent work.

3. No conduit shall be run below the head of a window or door.
4. Pull boxes and other appurtenances which require operation or maintenance shall be easily accessible. Do not cut or form handholes for operation or maintenance of appliances through walls or ceilings.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Test reports: Show that tests specified in Part 3 below demonstrate the specified results.
- C. LEED submittal:
 1. Product data for Indoor Environmental Quality (IEQ) Credit 4.1: For adhesives and sealants, include printed statement of VOC content.
 2. Product data for Indoor Environmental Quality (IEQ) Credit 4.4: For wood products such as plywood equipment backboards, include printed statement of non-urea-formaldehyde component present in material.

1.40 QUALITY ASSURANCE

- A. Provide materials and perform work in accordance with the electrical, building, fire, and safety codes and regulations of the state, county, or city in which the work is performed.
- B. Electrical control panels, equipment, materials and devices provided or installed as work of Division 26 shall bear UL label, or, if UL label is not available, the item shall be tested and labeled by a qualified testing agency, acceptable to authorities having jurisdiction, and in accordance with NFPA 70. Provide testing, if required, without addition to the contract sum.
- C. Qualifications of DVD documentation technician: For video documentation specified in "Operating Instructions (Demonstration)," employ persons knowledgeable in DVD optical storage media for video and audio production and editing.
- D. The project shall be LEED certified. See requirements specified in Division 01 and individual sections for LEED requirements, waste and air quality control.
- E. VOC content: Field-applied adhesives and sealants, limits per South Coast Air Quality Management District (SCAQMD), Rule No. 1168.
- F. Products shall contain no urea-formaldehyde content.

1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractors' and subcontractors' responsibilities are described in Division 01.

PART 2 - PRODUCTS

2.10 MATERIALS

- A. Electrical equipment backing panels: Plywood, DOC PS 1, Exposure 1, C-D Plugged, fire-retardant treated in accordance with AWPA C27, in thickness indicated, not less than 0.5 inch (13 mm) nominal.

1. One side finished.
- B. Wood-preservative-treated lumber: Treated by pressure process, AWPA C2, with chemicals acceptable to authorities having jurisdiction, and marked with treatment quality mark of an inspection agency approved by the ALSC Board of Review.
 1. Application: Treat items indicated on the drawings, and the following:
 - a. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, or waterproofing.
 - b. Wood sills, sleepers, blocking, and similar concealed members in contact with masonry or concrete.
 - c. Wood framing and furring attached directly to the interior of below-grade exterior masonry or concrete walls.
 - d. Wood framing members that are less than 18 inches (460 mm) above the ground in crawlspaces or unexcavated areas.
 - e. Wood floor plates that are installed over concrete slabs-on-grade.
- C. Aircraft cable: 0.25-inch (6-mm) steel wire rope, galvanized, construction 7 by 19 strands, minimum 7000 lbs (31138 N) breaking strength.

2.21 DATE-SENSITIVE EQUIPMENT

- A. Date-sensitive equipment: Systems, equipment, or components which use or process date and time data in order to perform their functions.
- B. Each item of date-sensitive equipment used in the project shall be warranted by the manufacturer to properly function and correctly use or process all time-related data for all dates and times which occur during a reasonable life expectancy of the equipment.

PART 3 - EXECUTION

3.03 INSTALLATION OF PRODUCTS AND EQUIPMENT

- A. Manufacturers' instructions: Except as modified by drawings or specifications, install products and equipment in accordance with manufacturers' instructions and recommendations applicable to the project conditions.
 1. Immediately notify Architect if a difference or discrepancy is found between manufacturers' instructions and the drawings or specifications.
- B. Install plywood backing panels with finished face exposed.

3.61 TESTS

- A. During the progress of the work and after completion, test the branch circuits and distribution system, and the low voltage alarm and signal systems.
- B. Results of the tests shall show that the wiring meets the requirements of this specification. Should any test indicate defect in materials or workmanship, immediately repair, or replace with new, the faulty installation, and retest the affected portions of the work.
- C. Furnish equipment and instruments necessary for testing.

D. Tests shall demonstrate the following:

1. Lighting, power, and control circuits are continuous and free from short circuits.
2. Circuits are free from unspecified grounds.
3. The resistance to ground of each non-grounded circuit is not less than one megohm.
4. Circuits are properly connected in accordance with the applicable wiring diagrams.
5. Circuits are operable. Demonstration shall include functioning of each control not less than ten times, and continuous operation of each lighting and power circuit for not less than 0.5 hour.

E. Test circuit breakers larger than 100 amps at full voltage.

F. Make voltage built-up tests with a voltage sufficient to determine that no short circuits exist.

G. Immediately repair defects and retest until systems are operating correctly.

H. Submit test reports.

3.81 OPERATING INSTRUCTIONS

A. Furnish the necessary technicians, skilled workers, and helpers to operate the electrical systems and equipment of the entire project for one 8-hour day.

B. Where specified in technical sections, provide longer periods required for specialized equipment.

C. Instruct the Owner or designated personnel in operation, maintenance, lubrication, and adjustment of systems and equipment.

D. The Operating and Maintenance Manual shall be available at the time of the instructions for use by instructors and Owner personnel.

E. Record each instruction session only in DVD media format (video and audio format), including both the sessions specified above and added sessions required in technical sections for specialized equipment. Provide one complete set of DVDs with each Operating and Maintenance Manual.

F. Schedule the general and specialized instruction periods for a time agreed upon by the Owner and Architect.

END OF SECTION 260500

SECTION 260501 - EXCAVATION AND FILL FOR ELECTRICAL WORK

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Trenching, backfilling, and compacting for electrical work underground inside the building and extending five feet beyond exterior building walls, and outside the building as shown on drawings.
- B. Restoring and reseeding grassed areas.

1.14 RELATED SECTIONS

- A. Cutting and patching: Division 01 and Section 260101.
- B. Repairing pavements: Division 32.
- C. Underground electrical ductbanks: Section 260544.
- D. Conduit: Section 260533.
- E. Service entrance: Section 260541.
- F. Identification for electrical systems: Section 260553.

1.20 REFERENCES

- A. ASTM D 1557: Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbs/cu ft (2700 kN-m/cu m).

1.30 SUBMITTALS

- A. General: Submit in accordance with Division 01 and Section 260101.
- B. Shop drawings: At the same scale as the contract drawings, showing field verified locations of utilities, and proposed detailed trenching plan.
- C. Product data: Seed and mulch.
- D. Certifications: Test reports showing that compaction meets specified requirements.

PART 2 - PRODUCTS

2.10 MATERIALS

- A. Backfill: Earth materials, free from perceptible amounts of wood, debris, or topsoil, free of frost at the time of placement, and not containing marl or other elements which tend to stay in a plastic state.
- B. Grass seed: Fresh new-crop seed, 90 percent pure and 85 percent germination. Mix: 70 percent Kentucky Bluegrass, 25 percent Red Fescue and 5 percent Red Top. Only strains of Kentucky Bluegrass found adaptable to Maryland shall be acceptable.

- C. Mulch: Free of sticks, weeds, or other foreign matter; either licorice root, tan root, or tan bark; fibrous by-product of extraction. Use only one type throughout the project.

2.12 EQUIPMENT

- A. Mechanical tampers for compacting backfill: Capable of exerting a blow equal to 250 pounds per square foot (12 kPa) of area of the tamping face.

PART 3 - EXECUTION

3.05 PREPARATION

- A. Contact local utility company underground information service (BGE Miss Utility) before beginning excavation outside buildings.
- B. The general locations of underground utilities are indicated on the drawings and are not to be assumed to be accurate or complete. Before beginning work, field check the area with the most accurate instruments available, such as Fisher Labs' Pipe and Cable Locators.

3.20 INSTALLATION

- A. Perform all excavating, cutting of paved areas, trenching, sheeting, shoring, backfilling, and compacting required for the proper installation of the work. Repair of pavement is specified in Section Division 32.
- B. Where obstructions are encountered, obtain written approval and make necessary changes in line, grade or location.
- C. Protect existing utilities from damage during excavation and backfilling. Repair damaged new or existing work at no addition to the contract sum. Bracing, shoring and other protection of existing utilities is part of this work.
- D. Do not damage or remove existing shrubs or trees including their root systems, without prior notification to the Architect.
- E. Provide temporary roadways over trenches with railings and other safeguards, including amber blinker lamps or other warnings for night use.
- F. Note the depths of footings. In cases where conduit is in close proximity to or below footings and where the natural earth under footings is disturbed, after the line is installed the voids shall be filled up to bottoms of such footings with solid concrete.

3.24 CUTTING

- A. Cut concrete and asphalt concrete with masonry saw prior to breaking it into smaller pieces for removal.
- B. Cut sidewalks perpendicular to the length at the closest existing joint that is a minimum of 24 inches back from either side of the top of the new trench.

3.25 TRENCHING

- A. Excavations inside the building shall be carefully planned. Stockpile excavated earth so as not to interfere with other construction. Dig trenches to the proper depths, providing extra depressions where required for hubs of pipes.
- B. Excavations outside the building shall generally follow the routes indicated on the drawings. Stockpile topsoil separately for later replacement. Excavations shall be of sufficient depths to provide, unless indicated otherwise on the drawings, a minimum cover as follows:
 - 1. Electrical conduit: Depth required by NFPA 70 (NEC).
- C. Trenches shall be of necessary depth and width for the proper laying of conduit with a minimum of 8 inches (205 mm) on each side of the joint.
 - 1. The sides shall be as nearly vertical as practicable. Unless local regulations are more strict, trenches 4 ft. (1220 mm) and deeper shall have shored sides as required by OSHA trenching regulations.
 - 2. The bottoms of trenches shall be accurately graded to provide uniform bearing and support for each section of conduit on undisturbed soil at every point along its entire length, except for bell holes.
 - 3. No greater length of trench shall be left open, in advance of the completed structure placed in it, than can be completed in that day's operation.
 - 4. Except where rock is encountered, do not excavate below the depths required. Where rock excavation is required, excavate to a depth of at least 6 inches (150 mm) below the trench depth and fill the overdepth with compacted crusher run or bank run stone or sand. Unauthorized overdepths in excavation shall be backfilled with crushed stone, slag or gravel, thoroughly compacted.
 - 5. Whenever wet or otherwise unstable soil is encountered, it shall be removed to the depth and extent directed, and the trench backfilled to the proper grade with crushed stone, slag or gravel.
- D. Should springs be encountered within the work area, or soft soil conditions at the elevations required for load bearing, immediately notify the Architect and do not place any portion of the work on such surfaces until instructions are received.
- E. Furnish and maintain pumps, flumes, gutters, and appurtenances if required to keep the excavations free from water. Water shall be directed to a point remote from building operations, shown on the approved shop drawing.

3.26 BACKFILL

- A. Place no backfill until the adjacent construction or the utility to be covered has been inspected, tested, and approved.
- B. Installing underground warning tape: Install in backfill above exterior buried lines not encased in concrete. Select legend and color appropriate for type of line. Install metallic lined tape for non-metallic lines. Install approximately 12 inches (305 mm) below grade.
- C. Electrical systems backfill:
 - 1. Backfill and compact in eight-inch (200-mm) layers, to level finished grade with the excavated materials approved for backfilling.
 - 2. Surplus earth shall be mounded up on excavation and left to settle. When directed by the Architect, surplus earth shall be removed and excavations leveled off to proper grade. Where direct burial cables are placed in trenches, first cover the cables with clean earth.

D. Structure backfill:

1. Do not backfill against structures with cement mortar joints until the mortar is at least twelve hours old.

3.27 COMPACTION

- A. Test in accordance with the requirements of ASTM D 1557.
- B. Compact under slabs, roads, and sidewalks to a 95 percent density.
- C. Compact unpaved areas to a 90 percent density.
- D. Backfill and compact trench in unpaved areas to within 4 inches (102 mm) of existing grade. Furnish and install compacted select topsoil for the final layer to finish even with existing grade. Remove surplus earth and rake unpaved areas for final planting.
- E. Take particular care in compaction of earth under joints of mechanical piping.

3.28 SEEDING

- A. Seed disturbed grass areas at the rate of 5 pounds (2.27 kg) per 1000 sq. ft. (92.9 sq. m), with the seed mix specified.
- B. Uniformly distribute seed with an approved machine to ensure a covering of plus or minus 1/4 inch (6 mm). Sow half of the seed in one direction and the rest at right angles.
- C. Do not seed during windy weather or when ground is wet or otherwise untillable. Seed between the dates of March 1st to May 1st or August 15 to October 15 unless otherwise approved in writing.

3.29 MULCHING

- A. Mulch seeded areas immediately following seeding with fibrous mulch evenly applied at an average rate of 2 tons per acre (4483 kg per hectare) so as to provide a loose depth of not less than 2 inches (50 mm).
- B. Wet down mulch, unless a heavy rain wets it, to the Architect's satisfaction, immediately after application.

3.41 RESURFACING

- A. Resurface sidewalks, roads, streets, and other paved areas as work of this section, matching the construction and finish of adjacent paving. Paving shall meet the requirements of Division 32.

END OF SECTION 260501

SECTION 260503 - ACCESS DOORS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Access doors for concealed electrical specialties requiring maintenance or manual operation.

1.14 RELATED SECTIONS

- A. Security systems devices: Division 28.
- B. Fire alarm devices: Section 28 3100.
- C. Voice and data devices: Division 27.
- D. Sound system devices: Division 27.
- E. Public address devices: Division 27.
- F. Electrical devices: Division 26.
- G. Identification for electrical systems: Section 260553.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data: Each type of access door.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Wall and ceiling access doors:
 - 1. Milcor, Inc.
 - 2. Cesco Products Company
 - 3. Karp Associates, Inc.
 - 4. Zurn Industries

2.11 WALL AND CEILING ACCESS DOORS

- A. Doors: Provide Milcor model listed, or similar type and equal quality by another acceptable manufacturer.
- B. Gray, prime-painted steel. Flush door, Types:
 - 1. Fire-rated where occurring in fire-rated walls.
 - 2. Style AP where occurring in acoustical plastered surfaces.
 - 3. Style K where occurring in hard plastered surfaces.
 - 4. Style MS stainless steel where occurring in masonry or ceramic tile surfaces.
 - 5. Style DW when occurring in dry wall construction.

- C. Sizes: As required for access to the particular device, but no less than 16 by 16 inches (405 by 405 mm).
- D. Recessed door panels for concealed type doors:
 - 1. Style AP: Acoustical plaster applied into recessed door panel for flush finish.
 - 2. Style AT: Matching acoustical tile applied into recessed door panel for flush finish.
 - 3. Style ATR: Matching material applied into recessed door panel for flush finish.
 - 4. Style DWR: Drywall panel applied into recessed door panel for flush finish.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Provide access doors in walls and inaccessible ceilings for concealed specialties and appliances that require manual operation or maintenance.
- B. Select appropriate size door for each particular application.

END OF SECTION 260503

SECTION 260507 - FIRESTOPPING FOR ELECTRICAL WORK

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Through-penetration firestopping in fire-rated construction.
- B. Through-penetration smoke-stopping in smoke partitions.

1.14 RELATED SECTIONS

- A. Sections specifying requirements for LEED rating are specified in Division 01.
- B. Conduit: Section 260533.
- C. Cable tray: Section 260536.

1.20 REFERENCES

- A. Underwriters Laboratories
 - 1. UL Fire Resistance Directory
 - 2. UL 1479: Through Penetration Firestops.
- B. American Society for Testing and Materials Standards:
 - 1. ASTM E 814: Standard Test Method for Fire Tests of Through-Penetration Firestops.

1.21 DEFINITIONS

- A. Assembly: Particular arrangement of materials specific to given type of construction described in referenced documents.
- B. Barriers: Time-rated fire walls, smoke barrier walls, time-rated ceiling/floor assemblies and structural floors.
- C. Firestopping: Methods and materials applied in penetrations and unprotected openings to limit spread of heat, fire, gasses and smoke.
- D. Penetration: Opening or foreign materials passing through or into barrier or structural floor such that full thickness of rated materials is not obtained.
- E. Sleeve: Metal fabrication or pipe section extending through thickness of barrier and used to permanently guard penetration. Sleeves are described as part of penetrating system in other sections and may or may not be required.
- F. System: Specific products and applications, classified and numbered by the rating agency to close specific barrier penetrations.

1.25 SYSTEM DESCRIPTION

- A. Design requirements

1. Fire-rated construction: Maintain barrier and structural floor fire resistant ratings including resistance to cold smoke at all penetrations.
2. Smoke barrier construction: Maintain barrier and structural floor resistance to cold smoke at all penetrations.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. LEED submittal:
 1. Product data for Indoor Environmental Quality (IEQ) Credit 4.1: For penetration firestopping, including printed statement of VOC content and chemical components.
- C. Product data: Manufacturer's specifications and technical data including the following:
 1. Detailed specification of construction and fabrication.
 2. Manufacturer's installation instructions.
- D. Certifications: Letters or forms showing acceptance by local authorities for systems without acceptance by a rating agency.

1.40 QUALITY ASSURANCE

- A. Products and assemblies shall be tested and labeled by an independent, nationally recognized testing and labeling authority.
- B. Comply with requirements for LEED certification specified in Division 01.
- C. Installer's qualification: Firm experienced in installation or application of systems similar in complexity to those required for this project, plus the following:
 1. Acceptable to or licensed by manufacturer, state, or local authority where applicable.
 2. At least 2 years' experience with systems.
 3. Successfully completed at least 5 projects of comparable scale, using these systems.
- D. Local and state regulatory requirements: Obtain acceptance for proposed assemblies not conforming to specific rating agency classifications or rated assemblies.
- E. Materials shall have been tested to provide fire rating at least equal to that of the construction in which they are to be installed.
- F. VOC content: Field-applied adhesives and sealants, limits per South Coast Air Quality Management District (SCAQMD), Rule No. 1168.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Packing and shipping:
 1. Deliver products in original unopened packaging with legible manufacturer's identification.
 2. Coordinate delivery with scheduled installation date, allow minimum storage at site.
- B. Storage and protection: Store materials in a clean, dry, ventilated location. Protect from soiling, abuse, moisture and freezing when required. Follow manufacturer's instructions.

1.60 PROJECT CONDITIONS

A. Environmental requirements:

1. Furnish adequate ventilation if using solvent.
2. Furnish forced-air ventilation during installation if required by manufacturer.
3. Keep flammable materials away from sparks or flame.
4. Provide masking and drop cloths to prevent contamination of adjacent surfaces by firestopping materials.
5. Comply with manufacturing recommendations for temperature and humidity conditions before, during and after installation of firestopping.

1.80 WARRANTY

- A. General project warranty and correction period, as required in general conditions and Division 01, requires repair or replacement of materials or systems which fail in joint adhesion, co-adhesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, or general durability or appear to deteriorate in any other manner not clearly specified by submitted manufacturer's data as an inherent quality of the material for the exposure indicated.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers and products: Those listed in the UL Fire Resistance Directory for the UL System involved, or rated for the application by Warnock Hersey or by another acceptable rating agency.

2.20 THROUGH-PENETRATION FIRESTOPPING OF FIRE-RATED CONSTRUCTION

- A. Provide systems or devices listed and labeled by a rating agency, and conforming to the construction type, penetrant type, annular space requirements and fire rating involved in each separate instance. The system shall be symmetrical for wall applications. Systems or devices shall be asbestos-free.
1. Additional requirements: Withstand the passage of cold smoke either as an inherent property of the system, or by the use of a separate product included as a part of the rated system or device, and designed to perform this function.

2.22 SMOKE-STOPPING AT SMOKE PARTITIONS

- A. Through-penetration smoke-stopping: Any system complying with the requirements for through-penetration firestopping in fire-rated construction is acceptable, provided that the system includes the specified smoke seal or will provide a smoke seal. The length of time of the fire resistance may be disregarded.

2.23 PENETRATIONS BY CABLE TRAYS

- A. Where cable trays penetrate fire-rated construction, provide firestopping materials that may be easily removed to allow installation and removal of cables from the tray. Provide materials similar to fire blocks, fire-stopping pillows, or fire-stopping bags.

2.70 ACCESSORIES

- A. Fill, void or cavity materials and forming materials: Classified for firestopping use, or included in a rated firestopping assembly, by a rating agency.

PART 3 – EXECUTION

3.02 EXAMINATION

- A. Verification of conditions: Examine areas and conditions under which work is to be performed and identify conditions detrimental to proper or timely completion.
 - 1. Verify barrier penetrations are properly sized and in suitable condition for application of materials.
 - 2. Do not proceed until unsatisfactory conditions have been corrected.

3.05 PREPARATION

- A. Clean surfaces to be in contact with penetration seal materials, of dirt, grease, oil, loose materials, rust, or other substances that may affect proper fitting, adhesion, or the required fire resistance.

3.20 INSTALLATION

- A. Provide firestop devices or assemblies for every opening and penetration in floors or fire-rated construction.
- B. Install penetration seal materials in accordance with printed instructions of the rating agency and in accordance with manufacturer's instruction.
- C. Ensure an effective smoke barrier in each sealed penetration. Install smoke stopping as specified for firestopping.
- D. Protect materials from damage on surfaces subject to traffic.
- E. Where large openings are created in walls or floors to permit installation of conduits, cables, cable tray, or other items, close unused portions of opening with firestopping material tested for the application.

3.60 FIELD QUALITY CONTROL

- A. Examine penetration seals to ensure proper installation before concealing or enclosing them.
- B. Keep areas of work accessible until inspection and acceptance by applicable authorities.
- C. Before substantial completion, patch and repair firestopping cut or penetrated by other construction work.

3.70 ADJUSTING AND CLEANING

- A. Clean up spills of liquid components.
- B. Neatly cut and trim materials as required.

C. Remove equipment, materials and debris, leaving area in undamaged, clean condition.

END OF SECTION 260507

SECTION 260519 - WIRES AND CABLES

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Wire and cable rated 600 V and less.
- B. Type AC cable is not permitted.

1.14 RELATED SECTIONS

- A. Underground ducts and structures: Section 260544.
- B. Conduits: Section 260533.
- C. Voice and data communication cables: Division 27.
- D. Video cables: Division 27.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data:
 - 1. Each type of wire and cable, including accessories.
 - 2. Include copies of UL certifications showing compliance with requirements in "Quality Assurance" below.

1.40 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. Products and installation shall comply with NFPA 70 and other applicable national, state, and local electrical codes.

PART 2 - PRODUCTS

2.20 LOW-VOLTAGE CONDUCTORS (600 V. MAX.)

- A. Conductors: Copper, 98 percent conductivity, rated for 75 degrees C, suitable for 600-volt duty, NEMA WC 70 Type THW, THWN, or THHN, solid for No. 10 and smaller and stranded for No. 8 and larger and when specifically noted.
- B. Conductor identification: Markings along outer braid denoting conductor size, type of insulation, and manufacturer's trade name, and color code. Identification shall extend to branch circuits and outlets. Use the color coding system tabulated below throughout the building's network of feeders and circuits, unless otherwise required by the authority having jurisdiction.
 - 1. Colors on conductors No. 10 and smaller, or No. 6 and smaller for grounded and grounding conductors: Solid colored insulation.

2. Colors on conductors No. 8 and larger, or No. 4 and larger grounded and grounding conductors: Colored tape wrapped a minimum of 6 inches (150 mm) on either end of conductor.

COLOR CODE				
VOLTAGE	NEUTRAL	PHASE		
		A	B	C
120-V, 2 wire	White	Black, Red, or Blue, depending on phase		
208/120-V wye, 3-phase, 4-wire	White	Black	Red	Blue
277-V, 2-wire	Gray	Brown, Orange, or Yellow, depending on phase		
480/277-V wye, 3-phase, 4-wire	Gray	Brown	Orange	Yellow
480-V delta, 3-phase, 3-wire		Brown	Orange	Yellow

- C. Wires used solely for grounding purposes shall be green, if insulated.
- D. Control wiring shall be coded with colors different from those used to designate phase wires.

2.21 WIRING ACCESSORIES

- A. Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service where installed.
- B. Twist-on wire connectors (dry locations): Color-keyed, Ideal Industries, Inc., Wingnut®, 3M Company "Scotchlok", or equal by King Innovation.
- C. Twist-on wire connectors (damp and wet locations): Ideal Industries, Inc., UnderGround®, models 60, 64, or 66 as appropriate; King Innovation DryConn®; or equal by 3M Company. Connectors shall be listed under UL 486D.
- D. Compression connectors: Color-keyed, 3M Company "Scotchlok"™ compressor connectors, "10000" series for copper conductors[, "20000" series for aluminum conductors,] or equal by Thomas & Betts (Blackburn) or IlSCO.
- E. Compression connectors (damp and wet locations): Protect the connector's with a waterproof system, UL-listed for direct burial and 600 volts: 3M Company 8420 series, Thomas & Betts Model DBSK82, or equal by IlSCO.
- F. Compression taps: Series CT-2 tap with CT-2C cover, or Series 54710 color-keyed compression taps, Burndy Corporation "Versitap" or equal by OZ/Gedney.
- G. Power distribution blocks: Equal to FCI Burndy "U-Blok."

2.23 PLENUM CABLES

- A. Plenum cable: Insulated with material equal to Dupont "Teflon FEP," UL classified for low flame and smoke-spread characteristics, for use in plenum areas without conduit in accordance with the requirements of NFPA 70.
 - 1. Communications cable: Type MPP or CMP in accordance with NFPA 70.

2.26 TYPE MC CABLE

- A. Metal-clad cable: NEMA WC 70 Type MC, copper, 600-V multiconductor with ground conductor. Solid copper No. 10 and smaller, stranded copper No. 8, conforming to ASTM B 3 or B 8.
- B. Fittings: Steel or malleable iron, equal to Appleton Electric Products.

2.29 DIRECT BURIAL CABLE, TYPE USE

- A. Direct burial service entrance cable: NEMA WC 70 Type USE, copper, 600-V multiconductor with ground. Solid copper No. 10 and smaller, stranded copper No. 8 and larger.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Provide wiring indicated in accordance with national, state, and local electric codes.
- B. Install wire and cable in raceways, except as indicated below.
- C. Wire and cable not installed in raceways:
 - 1. Support from building structure; do not support from ceiling supports, ceilings, or other utilities.
 - 2. Support no less than every 4 feet (1220 mm).

3.21 INSTALLING INTERIOR WIRING

- A. Sizes and locations: Minimum sizes shall be as follows, unless a larger size is indicated on the drawings.
 - 1. 120-V branch circuits, except as specified below:
 - a. Homerun from first outlet to panel: No. 12 when run is 50 feet (15,000 mm) or less; No. 10 when run is between 50 feet (15,000 mm) and 100 feet (30,000 mm); No. 8 when run is more than 100 feet (30,000 mm).
 - b. First outlet to other outlets: No. 12.
 - 2. Exit light and emergency lighting circuits: No. 10. Do not install in raceways, outlet boxes, or other locations with any other wiring system.
 - 3. Any system: Minimum No. 12 unless specified or shown on drawings to be smaller.
- B. Splicing shall be done in outlet boxes and junction boxes and not in conduit.
 - 1. Conductors No. 8 and larger: Terminated, spliced and taped, wherever practical, with compression connectors or solderless connectors. Use tools recommended by the manufacturer.

2. Splices in conductors No. 10 and smaller, including lighting fixtures: Made with wire connectors.
 3. Taps in conductors No. 6 and larger: Made with compression taps or power distribution blocks.
- C. Wiring, in fluorescent fixture channels, on rooftops and in other high ambient temperature areas shall be of types required by NFPA 70.
- D. Wires shall be neatly shaped in panels, troughs, boxes, and appurtenances.

3.22 COORDINATION WITH DEVICES AND EQUIPMENT

- A. Where conductor size or parallel conductors shown on drawings connect to terminals on devices or equipment which is not sized for the connection:
1. Provide a junction box as near the equipment as possible but no more than 10 feet (3 m) away. Obtain approval of location before installing.
 2. Provide conductor(s) sized to the ampacity of the equipment, from equipment to junction box.
 3. In the junction box, splice the conductors from the equipment to the conductors of sizes, or parallel conductors, shown on the drawings.

3.23 INSTALLING EXTERIOR WIRING

- A. Exterior lighting and 600-V circuits: Copper, No. 10 minimum, with an extra No. 10 (minimum) bare copper ground conductor.
- B. Splicing shall be done in outlet boxes and junction boxes and not in conduit. Treat these boxes as wet locations.
1. Conductors No. 8 and larger: Terminated, spliced and taped, wherever practical, with compression connectors. Use tools recommended by the manufacturer.
 2. Splices in conductors No. 10 and smaller, including lighting fixtures: Made with wire connectors.
 3. Taps in conductors No. 6 and larger: Made with compression taps or power distribution blocks.

3.25 INSTALLING CABLE RATED BELOW 100 VOLTS

- A. Install in conduit in walls, in concrete floors, above inaccessible ceilings, where exposed, and wherever it may not be accessible or may be subject to physical damage. Otherwise, install above accessible suspended ceilings and attached to building structure with approved standoff insulated clamps.
- B. Cable routes shall avoid hot utilities which might adversely affect the system's performance or result in damage to the cable. If cable must be placed close to such utilities, keep it separate and protect with insulation.
- C. Do not run cable in hangers used for pipes, electric conduits, or ceiling hangers, nor support it in any way by attachments to pipes, conduits, or ceiling hangers.
- D. Provide separate conduit systems for each low-voltage system.
- E. Each cable run shall contain an S loop or other means to accommodate expansion or contraction.

- F. Cable bends shall have a radius not less than the value recommended by the cable manufacturer.
- G. Tag cables connected to electronic equipment, to show function and the location of other end. Securely fasten labels to the cable.
- H. Where ceiling plenums are used for passage of air by heating and air conditioning system, install low-voltage cables and wiring in conduit or use UL listed plenum cable.

3.26 INSTALLING MC CABLE

- A. Install in compliance with NFPA 70.
- B. Locations: In drywall partitions and above ceilings. Do not install in masonry partitions or walls.
- C. Connect cable with wiring accessories specified above.
- D. Cable larger than No. 8 shall not be permitted.
- E. MC cable run to switches shall have a neutral conductor. This conductor is not indicated on the drawings.
- F. Homerun from panelboard to first outlet or switch: Wire in EMT or IMC raceway.

END OF SECTION 260519

SECTION 260521 - WIRING CONNECTIONS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Power and control wiring for equipment.

1.14 RELATED SECTIONS

- A. Equipment: Installed items requiring electricity, specified in other sections or shown on drawings.
- B. Motors: Sections 220513 and 230513.
- C. Control systems wiring: Section 230902.

PART 2 - PRODUCTS

2.10 MATERIALS

- A. Conduits, wires and cables, devices, and accessories as specified in other sections.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Provide power wiring from the motor starters to each motor and its manual controlling device. Interlock and control wiring related to the automatic temperature control system shall be provided under Section 230902, Control Systems Wiring.
 - 1. Make flexible or liquid tight connections as specified in Section 260533, Conduits.
- B. Except where provided with equipment, furnish and install manual pushbutton stations and pilot lights, with wiring. Where stations and pilot lights are grouped at central locations, mount them under a common faceplate.
- C. Rough in and connect to food service, laboratory, and shop equipment furnished under other sections and equipment furnished by Owner. Make connections as indicated on drawings with exact locations and details determined by approved shop drawings of the equipment.
 - 1. Under equipment sections, equipment will be set in position and the electrical devices and components furnished loose. Assemble, install, and wire under this section.
 - 2. Accomplish rough-in from walls with flush outlet boxes and from floors by means of conduit couplings finishing flush with finished floor.
- D. Certain equipment, as indicated, will be furnished with control panels and auxiliary control components. Mount the panels, furnish and install source wiring and disconnects, and completely connect controls and motors.
- E. Provide source wiring, connections, and disconnects for mechanical heating, ventilating, and air-conditioning (HVAC) equipment specified in Division 23. Refer to sections of Division 23 for equipment and controls.
 - 1. Provide weathertight enclosures for disconnects for outdoor equipment.

2. Mount starters where required, and provide proper size overload protection.
 3. Where capacitors are required for power factor correction as specified in 230513, Common Motor Requirements for HVAC Equipment, connect the capacitors.
- F. Roof exhaust fans will be equipped with factory-wired disconnects located adjacent to the motor under the ventilator hoods as specified in Section 233400, HVAC Fans. Exhaust fans shall be controlled by various means as indicated on drawings.
1. For fans shown to be manually controlled, furnish and install a manual motor starting switch with pilot light, located where indicated.
 2. Where necessary for larger and three-phase motors, provide magnetic starters.
 3. Where fans are provided with electrically operated dampers, provide wiring and relays for single-phase damper operators on three-phase motors.
- G. Cabinet unit heaters will be equipped with a manual motor starting switch with overload protection, located within the cabinet. Provide source wiring to line side of this switch. Automatic control of these units will be as described in Control Sequences.
- H. Where a Division 23 section requires installation of equipment under supervision of equipment manufacturer's representative, coordinate electrical installation to cooperate with representative's requirements.
- I. Provide power sources for Owner-furnished equipment.
- J. Provide power and control wiring for fire protection system pumps, controllers, alarm panels and alarm bell. Mount bells and silence switches where indicated. Provide plastic nameplates under bell and switch.
- K. Provide power and control wiring for emergency generator, controllers, remote control panels and remote alarm bell. Mount remote bell and silence switch where indicated. Provide plastic nameplates under bell and switch.
- L. Provide wiring where required to time clocks provided as specified in automatic temperature controls sections.

END OF SECTION 260521

SECTION 260526 - GROUNDING AND BONDING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Grounding and bonding electrical systems and equipment.
- B. Ground system test.

1.14 RELATED SECTIONS

- A. Lightning protection: Section 264113.
- B. Gas flexible pipe connector: Section 231123.

1.20 REFERENCES

- A. ANSI/TIA/EIA J-STD-607
- B. IEEE STD 142
- C. NFPA 70
- D. ASTM F467 and F468
- E. UL 467

1.21 DEFINITIONS

- A. Area served by a separately-derived system: The area within the building that contains any part of a circuit of the system.
- B. IBGB: Intersystem Bonding Termination Grounding Busbar.
- C. TMGB: Telecommunications Main Grounding Busbar.
- D. TGB: Telecommunications Grounding Busbar.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data: Ground rods and connections
- C. Certifications: System test.

PART 2 - PRODUCTS

2.20 MANUFACTURED UNITS

- A. Ground conductor, unless specifically noted otherwise, shall be copper, 98 percent conductivity, solid for No. 10 AWG and smaller and stranded for No. 8 AWG and larger.

- B. Grounding busbar: Predrilled rectangular bars of electro-tin plated copper, 0.25 inches (6.3 mm) thick, 12 inch (300 mm) long, unless otherwise indicated on drawings, with 0.3125 inch or 0.4375 inch (7.9 mm or 11.1 mm) diameter holes horizontally spaced 1 to 1.125 inches (25.4 to 28.6 mm) apart.
 - 1. Intersystem bonding termination grounding busbar (IBGB) and telecommunications main grounding busbar (TMGB) shall be 4 inches (101.6 mm) wide, with four rows of holes. Telecommunications main grounding busbar shall comply with ANSI/TIA/EIE J-STD-607.
 - 2. Other grounding busbars shall be 2 inches (50.8 mm) wide with two rows of holes. Each telecommunications ground busbar (TGB) shall comply with ANSI/TIA/EIA J-STD-607.
 - 3. Stand-off insulators for busbar shall be flame-resistant fiberglass-reinforced thermoset polyester, UL recognized per UL Standard 891.
- C. Ground rods: Copper bonded steel, 0.75 inch diameter by 10 feet long, one end pointed and the other end tinned, equal to the product of Erico International Corporation.
- D. Mechanical type ground connectors:
 - 1. Connectors: IEEE 837 and UL 467 compliant, equal to FCI Burndy G Series, listed for use for specific types, sizes, and combinations of conductors and connected items.
 - 2. Nuts, bolts, and washers: Silicon bronze alloy type B per ASTM F467 and F468.
- E. Exothermic type ground connections: Exothermic welding systems shall be equal to "Cadweld," manufactured by Erico International Corporation.
- F. Lugs: Lugs shall be two- or four-hole, equal to Burndy Hylug series.

PART 3 - EXECUTION

3.21 INSTALLATION, GENERAL

- A. Provide the complete grounding of conduit systems, electrical equipment, conductor and equipment enclosures, motors, transformers, and neutral conductors in accordance with applicable codes. Grounded phase and neutral conductors shall be continuously identified. Continuity of metal raceways shall be insured by double locknuts.
- B. Furnish and install main grounds for secondary electrical service to cold water main in accordance with NEC requirement. In addition to the cold water ground, provide ground rods as indicated or as required by NEC and applicable codes.
- C. Grounding busbar: Busbars shall stand off the wall a minimum of 2 inches (50.8 mm). Mount 6 inches (152.4 mm) above finished floor unless otherwise indicated. Insulate the busbar from its supports.
 - 1. Conductors connecting busbar to other busbars, and to the grounding electrode system shall be attached to busbar with exothermic welds.
 - 2. Connect other conductors to busbar using lugs.
- D. Install copper grounding jumpers of 3/0 copper cable around each main water valve in the building. Install copper grounding jumpers around conduit expansion fittings. Jumpers shall be of adequate current carrying capacity corresponding to size of conduit.
- E. Ground system connections which are beneath the floor and in a concealed or inaccessible location shall be brazed or welded. Brazing and welding shall be "CADWELD."

- F. Separately-derived 120/208-volt three phase wye electrical systems originating in transformers shall be grounded at the transformer neutral terminal:
1. The grounding electrode for the system shall be whichever one of the following that is closest to the transformer:
 - a. Building's grounding electrode.
 - b. Steel structural member of the building conforming to NEC requirements for grounding electrodes.
 - c. First five feet of the water service piping to the building.
- G. Separately-derived three phase wye electrical systems originating in generators shall be grounded at the generator neutral terminal:
1. The grounding electrode for the outdoor generator shall be a ground rod.
 2. The grounding electrode for the indoor generator shall be whichever one of the following that is closest to the generator:
 - a. Building's grounding electrode.
 - b. Steel structural member of the building conforming to NEC requirements for grounding electrodes.
 - c. First five feet of the water service piping to the building.
- H. Bonding separately-derived systems:
1. Each metal water piping system, not used as the electrical system's grounding electrode, in the area served by the electrical system shall be bonded to the electrical system's neutral by a system bonding jumper.
 2. If exposed structural metal is not used as the grounding electrode for the system, bond exposed structural metal in the area served by the electrical system to the system's neutral by a system bonding jumper.
 3. If a metal water piping system in the area served by the electrical system is bonded to exposed structural metal by a NEC-compliant bonding jumper, then only one of the two (piping or structure metal) need to be bonded to the electrical system's neutral.
- I. 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 bonding so vibration is not transmitted to rigidly mounted equipment.
 3. Use exothermic-welded connections for outdoor locations; if a disconnect-type connection is required, use a bolted clamp secured with a minimum of two bolts and lock washers.
- J. Ufer ground (concrete-encased grounding electrode): Fabricate according to NFPA 70; use a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG.
1. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.
 2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

3.23 EQUIPMENT GROUNDING AND BONDING

- A. Provide insulated equipment grounding conductors to all feeders and branch circuits.
- B. Air-duct equipment circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- C. Water heater, heat tracing, and antifrost heating cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- D. Isolated grounding receptacle circuits shall be provided with an additional equipment grounding conductor insulated from the normal equipment grounding conductor.
 - 1. Provide an isolated equipment grounding conductor for connection to the isolated ground type receptacle's grounding terminal. The isolated equipment grounding conductor shall be in addition to the system equipment grounding conductor used to bond the outlet box to the grounding system.
 - 2. Multiple isolated ground type receptacles on a single circuit may use a common insulated equipment ground conductor for connection to the grounding terminals.
 - 3. Terminate the circuit's insulated equipment grounding conductor in the circuit's originating panelboard on an insulated equipment ground bar (insulated from the panel's normal equipment ground bar and panel enclosure).
 - 4. Provide an insulated equipment grounding conductor from the panel's insulated equipment ground bar to the originating system's (service or separately derived system) neutral terminal. This conductor shall follow the route of the panel feeder through any intervening distribution equipment to the originating system.
 - 5. Insulating equipment grounding conductors that do not have insulation as described in Part 2 shall be marked (where visible to normal inspection) with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- E. Signal and communication equipment: In addition to grounding and bonding required by NFPA 70, provide grounding systems complying with requirements in ANSI/TIA/EIA J-STD-607-A.
 - 1. Telephone and data equipment may share a common grounding system.
 - a. Provide a No. 4 AWG minimum conductor from the IBGB to a TMGB, located in the telecommunications entrance facility.
 - b. Provide a TGB in each telephone and data wiring closet. Where a telephone and data terminal cabinet is not in a wiring closet, provide a TGB next to it.
 - c. Provide No. 4 AWG minimum conductors to bond the TMGB to TGB's.
 - d. Where a TMGB or TGB is in a room with a panelboard providing circuits to the telephone or data equipment in the room, locate the busbar as close as is practical to the panelboard, and bond the panelboard's equipment ground or enclosure to the busbar.
 - 2. For other communication equipment, such as fire alarm, intercom, CATV, and security panels, when located in a room other than where the IBGB, TMGB, or TGB is, provide a grounding busbar in the same room as the equipment. Bond the grounding busbar to the IBGB, TMGB, or TGB with a No. 4 AWG minimum conductor.
- F. Gas piping:

1. Comply with NFPA 54.
2. Provide bonding jumpers for each length of corrugated stainless-steel tubing (CSST).
 - a. Jumpers shall be No. 6 AWG or the same size as the equipment grounding conductor serving the equipment served by the CSST, whichever is larger.
 - b. Install in accordance with CSST manufacturers' instructions and NFPA 54.

3.59 IDENTIFICATION

- A. Comply with requirements in Section 260553, Identification for Electrical Systems, for instruction signs. The label or its text shall be green.
- B. Install labels at the ends of telecommunications bonding conductors and the grounding electrode conductor where exposed.
 1. Label text: "If this connector or cable is loose or must be removed for any reason, please call the building telecommunications manager."

3.61 GROUNDING SYSTEM TEST

- A. Ensure that grounding system is continuous and that resistance to earth is not more than 10 ohms.
- B. Test each ground rod for resistance to earth before making connections to rod; tie grounding system together and test for resistance to earth.
- C. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall.
- D. Submit written results of each test including location of rods as well as resistance and soil conditions at time measurements were made.

END OF SECTION 260526

SECTION 260528 - EQUIPMENT FOUNDATIONS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Equipment foundations (housekeeping pads).
- B. Outdoor equipment foundations.

1.14 RELATED SECTIONS

- A. Service entrance: Section 260541.
- B. Generators: Section 263213.
- C. Transformers: Section 262200.
- D. Switchboards: Section 262413.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data: Concrete mix, grout, reinforcement, and accessories.
- C. Certifications: Test report showing strength of concrete.

PART 2 - PRODUCTS

2.11 CONCRETE

- A. Concrete: 3,000 psi (20.7 MPa) compressive strength at 28 days.

2.12 GROUT

- A. Non-shrink grout: Premixed, consisting of non-metallic aggregate, cement, water-reducing and plasticizing agents; capable of developing minimum compressive strength of 7,000 psi in 28 days.
 - 1. Five Star Products, Inc. "Five-Star Grout"
 - 2. L&M Construction Chemicals, Inc. "Crystex"
 - 3. Sonneborn "SonogROUT"

2.13 METAL REINFORCEMENT

- A. Reinforcing bars: Deformed steel bars in accordance with ASTM A615, Grade 60, clean and free from loose rust, scale, or other coatings that will reduce bond.
- B. Welded wire fabric reinforcing: ASTM A 185 No. 6 steel wire spot-welded at intersections and of size 6 by 6 inch mesh.
- C. Metal accessories: Include spacers, chairs, bolsters, ties, and other devices necessary for properly placing, spacing, supporting and fastening reinforcement in place.

PART 3 – EXECUTION

3.21 INSTALLING EQUIPMENT FOUNDATIONS (HOUSEKEEPING PADS)

- A. Provide 4-inch-high concrete foundations (housekeeping pads) for floor-mounted equipment unless otherwise noted. Furnish foundations, bolts, sleeves, and appurtenances and install as recommended by equipment manufacturer. Anchor the concrete foundations by dowels inserted into the floor slab. Provide welded wire fabric reinforcement.
- B. Unless otherwise specified, install concrete work in accordance with the requirements of Division 03.
- C. Equipment shall be properly aligned. Level and grout equipment where necessary. Support conduit independently of equipment and so as not to cause a strain or thrust.
- D. Coordinate exact locations and configurations of equipment, foundations, and supports with the approved shop drawings of the equipment.

3.22 INSTALLING OUTDOOR EQUIPMENT FOUNDATIONS

- A. Provide equipment foundations of size and thickness indicated.
- B. Place reinforcement accurately in position shown, securely fasten, and support to prevent displacement before or during pouring. Clean, bend, place, and splice reinforcement in accordance with approved shop drawings. Lap ends and sides of mesh reinforcement in slabs not less than one mesh.
 - 1. Coverage of main reinforcing shall be as follows: Slabs, 0.75 inch (19 mm); concrete poured against earth, 3 inches (75 mm); other locations, 2 inches (50 mm).
- C. Properly align, level, and grout equipment.

END OF SECTION 260528

SECTION 260533 - CONDUITS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Conduit and accessories, aboveground and below ground where not in duct banks.

1.14 RELATED SECTIONS

- A. Exterior duct banks and handholes: Section 260544.
- B. Firestopping: Section 260507.
- C. Boxes: Section 260534.
- D. Trenching: Section 260501.

1.21 DEFINITIONS

- A. FMC: Flexible metal conduit.
- B. LFMC: Liquid-tight flexible metal conduit.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data:
 - 1. Each type of conduit included in the work, and related fittings.
 - 2. Accessory materials.
 - 3. Hangers and fasteners.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following:
- B. Steel conduit and tubing:
 - 1. AFC Cable Systems, Inc. (FMC and LFMC)
 - 2. Allied Tube & Conduit; a Tyco International Ltd-Co.
 - 3. O-Z/Gedney, Unit of General Signal
 - 4. Wheatland Tube Co.
- C. Steel conduit fittings:
 - 1. Appleton Electric Co.
 - 2. Cooper Crouse-Hinds.
 - 3. Hubbell, Inc.; Killark Electric Manufacturing Co.
 - 4. O-Z/Gedney; Unit of General Signal.
 - 5. Spring City Electrical Manufacturing Co.

6. Thomas & Betts Corporation.

D. Nonmetallic conduit, tubing and fittings:

1. Allied Tube & Conduit; a Tyco International Ltd. Co.
2. Arnco Corp.
3. Beck Manufacturing
4. CANTEX Inc.
5. Certainteed Corp.; Pipe and Plastics Group
6. Lamson & Sessions; Carlon Electrical Products

E. Wiring troughs and fittings:

1. Hoffman Engineering Co.
2. Lamson & Sessions, Carlon Electrical Products
3. Square D Schneider Electric

F. Conduit hangers and supports:

1. Thomas & Betts "Kindorf"
2. Tyco Power-Strut
3. Unistrut Diversified Products

G. Fasteners:

1. Caddy Fasteners by Erico Products Inc
2. ITW Ramset "Red Head"
3. Wej-It Fastening Systems

2.20 CONDUIT AND FITTINGS

A. Galvanized steel conduit: Hot-dip galvanized with threads galvanized after cutting, one of the following:

1. Rigid full weight, heavy-wall steel conduit (RGS) conforming to UL 6 and ANSI C80.1.
2. Intermediate steel conduit (IMC) conforming to UL 1242 and ANSI C80.6.

B. Steel conduit fittings: Cast malleable iron fittings with smooth finish and full threaded hubs. Include steel or malleable iron locknuts, bushings, and other fittings.

1. Insulating bushings: Equal to Thomas & Betts Series 22.
2. Hub fittings with recessed sealing ring and nylon insulated throat equal to Thomas & Betts Series 370.
3. Fittings for exposed locations: Conduit outlet bodies, zinc or cadmium plated.

C. Electrical metallic tubing (EMT): Hot-dip galvanized or sherardized thin-wall steel conduit conforming to UL 797 and ANSI C80.3.

D. Connectors and couplings for EMT: Concrete- or rain-tight, compression type, made of zinc- or chromium-plated steel. Connectors shall have nylon insulating throats.

1. Compression connector equal to Thomas & Betts No. 5223.
2. Compression coupling equal to Thomas & Betts No. 5220.

- E. Flexible metal conduit (Type FMC): Made of sheet metal strip, interlocked construction, conforming to UL 1.
- F. Liquidtight flexible metal conduit (Type LFMC) shall conform to UL 360.
- G. Connectors for flexible metal conduit: Equal to angle wedge "Tite-Bite" with nylon insulated throat, Thomas & Betts Series 3110 and 3130.
- H. Liquidtight type connectors: UL 14814A. Fittings: With nylon insulated throat, equal to Thomas & Betts Series 5331.
- I. Plastic conduit: Polyvinyl chloride (PVC) Schedule 40, rated for use with 90-degree conductors, for exposed, underground, and encased applications, complying with NEMA Specification TC-2 and UL 651.
- J. Plastic conduit fittings and cement:
 - 1. Fittings: Complying with NEMA TC 3 and UL 514.
 - 2. Cement: Solvent cement made by the manufacturer of the conduit and fittings.
- K. Wiring troughs: Steel wiring trough with hinged cover, UL listed as wireways and auxiliary gutters, equal to Square D "Square-Duct."
 - 1. Cover: Opening complete width and length of trough;
 - 2. Finish: Baked enamel.
- L. Fittings for wiring troughs: Made with removable covers to permit installation of a complete system with access to wires throughout the system, UL listed with the troughs. Connections: Threaded screws at every connector.
- M. Weatherproof expansion fittings: With bonding jumpers, equal to O-Z/Gedney types AX and TX.

2.21 SLEEVES FOR RACEWAYS

- A. Steel pipe sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
 - 1. Sleeves for exterior walls: Anchor flange welded to perimeter.
- B. Sleeves for rectangular openings: Galvanized sheet steel of length to suit application. Minimum thickness:
 - 1. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm): 0.052 inch (1.3 mm).
 - 2. 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): 0.138 inch (3.5 mm).
- C. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 260507.

2.22 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and conduit.

1. Sealing elements: EPDM or NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
2. Pressure plates: Stainless steel. Include two for each sealing element.
3. Connecting bolts and nuts: Stainless-steel of length required to secure plates to sealing elements. Include one for each sealing element.

2.23 ACCESSORY MATERIALS

- A. Pull rope: Polypropylene, thickness, tensile strength, and work load selected to meet project load requirements.
- B. Caps and plugs: Equal to Thomas & Betts Series 1470.
- C. Lubricant: Equal to Ideal Industries, Inc. "Yellow 77". UL approved.
- D. Bituminous protective coating: Coal tar based, self-priming on steel, applied in a wet film thickness at least 22.0 mils (559 microns) per coat.
- E. Rust inhibitive paint: Alkyd based, equal to Benjamin Moore Super Spec HP D.T.M. Alkyd Low Lustre P23; white, black, or bronzetone; applied in a wet film thickness of at least 2.9 mils.

2.24 CONDUIT HANGERS

- A. Adjustable hangers: Equal to Kindorf C-711 lay-in hanger or C-710 Clevis hanger.
- B. Trapeze hangers: Constructed of channels with Kindorf C-105 notched steel straps.
- C. Channels: Steel, 1.5 inches (38 mm) wide with 7/8-inch (22-mm) continuous slot, gages and weights equal to Kindorf B-900 series.
- D. Beam clamps: Equal to Kindorf E-160 or U-569 adjustable type, for connecting hanger rod to steel beam.
- E. Hangers for conduit 1.0 inch (27 mm) and smaller, through or below bar joists: "Hang-on" hangers attached to joists with Minerallac scissor clips or two-piece stud clips.
- F. Finish: All hangers, assemblies, plate washers, rods, locknuts, channels, bolts, and appurtenances shall be hot-dip galvanized.

2.25 FASTENERS

- A. General: Select fasteners such that load applied does not exceed one-fourth of manufacturer's load capacity in 3500 psi (24000 kPa) concrete.
- B. Fasteners to concrete: Self-drilling type expansion anchors, or machine bolt drop in anchors for drilled holes. Fasteners to concrete ceilings shall be vibration- and shock-resistant.
- C. Fasteners to drywall or cavity wall: Toggle bolts, hollow-wall drive anchors, or nylon anchors as required.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Provide complete, separate and independent raceway system for each of the various wiring systems including, but not limited to, the following:

1. Lighting
2. Power
3. Exit Lighting*
4. Emergency Lighting System*
5. Fire Alarm System
6. Clock and Program
7. Low Voltage Control System
8. Control Wiring
9. Voice and Data Systems
10. Sound System
11. Television System
12. Security Systems

*These wiring systems may be installed in common raceways.

- B. Wire all raceway systems completely, except where otherwise indicated, as shown on drawings and as required for satisfactory operation of each system.
- C. Where wiring troughs are required or used to facilitate the installation, amply size them to accommodate conductors, in accordance with NFPA 70.
- D. Types and locations of conduits are scheduled at the end of the section.
- E. Do not install conductors or pull rope during installation of conduit.
- F. Where conduit is connected to a cabinet, junction box, pull box, or auxiliary gutter, protect the conductors with an insulating bushing. Provide locknuts both inside and outside the enclosure. Where conduit is stubbed up to above ceilings for future wiring, close ends with bushings.
- G. Bituminous protective coating:
1. Coat exposed threads on steel conduits in concrete slabs at couplings and fittings, after joints are made up.
 2. Coat metallic conduits below grade not in concrete, and where emerging from below grade or slabs, four inches above and below grade or slab.
- H. Rust-inhibitive paint:
1. Exposed threads of exterior conduit.
 2. All unfinished metal components.
- I. Make turns in conduit runs with manufactured elbows or using machines or tools designed to bend conduit. Turns shall be not less than the various radii permitted by NFPA 70.
- J. Sizes:
1. Do not use conduit smaller than 0.75 inch (21 mm), except where otherwise indicated.

2. Feeder conduits shall be as large as indicated, or as required by NFPA 70 (whichever is larger). Do not install more than one feeder in a single conduit.
 3. Conduit sizes shown on drawings are based on Type THW THHN/THWN wire.
- K. Make vertical runs plumb and horizontal runs level and parallel with building walls and partitions.
- L. Ground conduits as required by NFPA 70.
- M. Where conduits pass through building expansion joints, and wherever relative movement could occur between adjacent slabs, equip with weatherproof expansion fittings and bonding jumpers.
- N. Where conduits through roof cannot be installed inside equipment or pipe curbs, flash them in accordance with the SMACNA Architectural Manual.
1. Coordinate flashing details and materials with manufacturer and installer of roofing system.
 2. Pitch pockets are not permitted.
- O. Run conduits concealed in new construction except where connecting to surface-mounted cabinets and equipment, and in electrical and mechanical equipment spaces. Install conduit above suspended ceilings and within walls and partitions.
- P. From each flush-mounted lighting or power panelboard, provide at least four 0.75-inch empty conduits, to terminate in furred ceiling space above. On floors above ground floor, provide two additional 0.75-inch conduits terminating in furred ceiling space below. Cap these conduits.
- Q. Immediately after each run of conduit is completed, test it for clearance, smooth the joints, and close at each end with caps or plugs to prevent entrance of moisture or debris.
- R. Conduit installed outdoors or at indoor locations exposed to continuous or intermittent moisture shall provide a liquidtight seal. Use steel or malleable iron hub fittings. Coat exposed threads with bituminous protective coating.
- S. Install no conduit in these locations:
1. Setting beds for terrazzo or tile.
 2. Concrete toppings, unless specifically approved by Structural Engineer.
- T. Conduit in concrete decks above grade: Not permitted.
- 3.21 INSTALLING PULL BOXES, JUNCTION BOXES, OUTLET BOXES
- A. Install as specified in Section 260534, Boxes.
- B. Install pull or junction boxes in long runs of conduits or where necessary to reduce the number of bends in a run.
1. Select inconspicuous locations. Do not install until locations have been approved by the Architect.
 2. Install boxes flush with wall or ceiling surfaces, with flat covers. Where removable ceiling units are used, locate boxes above ceilings.
- C. Verify door swings with door frame installed before locating switch outlets.

3.22 INSTALLING FLEXIBLE CONDUIT

- A. Installation shall comply with NFPA 70.
 - 1. Minimum length: Two feet (610 mm).
 - 2. Maximum length: Six feet (1830 mm).
- B. Make immediate connections to recessed lighting fixtures, speakers, and other equipment in suspended ceilings with flexible metal conduit. Include sufficient slack to permit removal of fixture or equipment.
- C. Make immediate connections to motors and transformers with liquidtight flexible conduit. Include sufficient slack to reduce the effects of vibration.
- D. In wet locations, install liquidtight type, in such a manner that liquid tends to run off the surface and not drain toward the fittings.
- E. Where fittings are brought into an enclosure with a knockout, install a gasket assembly consisting of an O ring and retainer on the outside.

3.23 INSTALLING PULL ROPE AND CONDUCTORS

- A. After conduit is installed, fish pull rope. After completion of the work of this project, pull rope shall remain in conduits identified as to be left empty.
- B. Do not use a pull rope that has a tensile strength of more than one of the conductors of a two-wire circuit, more than two of the conductors of a three-wire circuit, or more than three of the conductors of a four-wire circuit.
- C. Do not pull conductors into the conduits until the system is entirely completed and wet building materials are dry.
- D. Use only a lubricant approved for use with conductor materials and pull rope materials.

3.24 INSTALLING SLEEVES

- A. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 260507.
- 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. 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.
- D. Cut sleeves to length for mounting flush with both surfaces of walls.
- E. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
- F. Size pipe sleeves to provide 0.25-inch (6.4-mm) annular clear space between sleeve and raceway unless sleeve seal is to be installed.

- G. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
- H. Interior penetrations of non-fire-rated walls and floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint.
- I. Fire-rated-assembly penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Section 260507.
- J. Roof-penetration sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
- K. Exterior-wall penetrations: Seal penetrations using 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.

3.25 SLEEVE-SEAL INSTALLATION

- A. Install to seal exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.26 INSTALLING CONDUIT HANGERS

- A. Single runs of overhead conduits 1.25-inch (35-mm) size and larger shall be supported by adjustable hangers, using 0.375-inch (10-mm) rods for conduits up to 2.0 inch (53-mm) size and 0.5-inch (13-mm) rods for conduits larger than 2.0 inches (53 mm).
- B. Support groups of conduits run in parallel on trapeze hangers suspended from 0.5-inch (13-mm) hanger rods.
- C. Space hangers not over 10 feet (3 m) apart. Support conduits within 3 feet of each outlet, junction or pull box.
- D. Below bar joist construction, support hangers from a length of structural channel, welded to the top chords of at least two joists.
- E. Where large numbers of conduits are grouped together, stagger individual hangers so as not to concentrate the load on a few joists.
- F. Where hanger rods are attached to structural beams, use adjustable beam clamps.
- G. Below precast plank construction, hanger rods shall pass through the precast planks and be secured on top side with nut, locknut and plate washer. Plate washers shall be at least 4 inches (102 mm) square and 0.125 inch (3.2 mm) thick. Top of hanger assembly shall be concealed in the concrete fill which will be placed over the planks.
- H. Attach hanger rods to concrete with expansion bolts and anchors.

3.29 INSTALLING UNDERGROUND CONDUIT, GENERAL

- A. Depth:
 - 1. Buried under building slabs: Top of conduit no less than 12 inches below the vapor barrier. Seal around conduits where they penetrate the vapor barrier.
 - 2. Outside building: Top of conduit no less than 24 inches below finish grade.
- B. Slope: At least 3 inches in 100 feet away from buildings and toward manholes or other drainage points.
- C. Cleaning: At the completion of each run, in each conduit, first run a testing mandrel not less than 12 inches (305 mm) long with diameter 0.25 inch (6.35 mm) less than the inside diameter of the conduit; then draw through a stiff-bristled brush until all particles are removed. Immediately install conduit plugs.
- D. Except at conduit risers, make changes in direction of runs, either vertical or horizontal, by long sweep bends. Bend may be made up of one or more curved or straight sections or combinations. Use manufactured bends with a minimum radius of 36 inches.
- E. Where underground nonmetallic conduit runs penetrate floor slabs, penetrations shall be made with metallic elbows. Coat metallic elbows with bituminous protective coating.

3.30 INSTALLING UNDERGROUND CONDUIT WITHOUT CONCRETE ENCASEMENT

- A. Run conduit in straight lines except as necessary.
- B. Trenches: At least three inches (80 mm) clearance on each side of the conduit.
- C. Warning tape: Install in backfill approximately 12 inches (300 mm) below grade.
- D. Under existing roads and paved areas not to be disturbed, jack rigid steel conduit into place.

3.90 SCHEDULE OF LOCATIONS

- A. RGS with screw joint couplings:
 - 1. Conduits in concrete slabs except where noted to be plastic.
 - 2. First five feet of conduit extending outside building.
 - 3. Under roads and paved areas where existing pavement is not to be disturbed, extending at least five feet beyond edges of pavement.
 - 4. Elbows penetrating floor slabs.
- B. IMC with screw joint couplings:
 - 1. Conduits 2.0 inch (53-mm) size and larger except as noted above to be rigid steel.
 - 2. Wiring to exterior equipment.
- C. EMT: Sizes 1.5 inch (41 mm) and smaller except as noted above.
- D. Plastic with solvent cement joints:
 - 1. For exterior circuits, directly buried, except first five feet from building.
 - 2. Where noted under concrete slab, concrete encased.

3. Where noted under concrete slab, direct buried.
4. Where noted in concrete slabs.
5. For concrete encased duct banks.

END OF SECTION 260533

SECTION 260534 - BOXES

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Boxes with covers.

1.14 RELATED SECTIONS

- A. Conduits: Section 260533.
- B. Access doors: Section 260503.
- C. Wiring devices: Section 262726.
- D. Outlet boxes where required for special systems: Provided by the equipment manufacturers of the various systems.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data: Each type of box included in the project.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following:
- B. Boxes:
 - 1. Appleton/EGS Electrical Group
 - 2. RACO/Hubbell Electrical Products
 - 3. Steel City/Thomas & Betts
- C. Floor boxes and poke-through fittings:
 - 1. Hubbell, Inc., Kellems
 - 2. Mono-systems, Inc.
 - 3. Steel City/Thomas & Betts
 - 4. Wiremold

2.10 MATERIALS

- A. Outlet, switch, and junction boxes:
 - 1. Sheet metal: NEMA OS 1, sherardized or galvanized stamped.
 - 2. Cast-metal, where required for weather-exposed or exposed locations: NEMA FB 1, ferrous alloy or aluminum, Type FD, with gasketed cover.

2.21 BOXES FOR WALLS AND PARTITIONS

- A. Outlet boxes in concrete construction: Octagonal, two-piece type, of sufficient depth to keep conduits not closer than 1 inch (25 mm) to surface.
- B. Switch and receptacle boxes in masonry partitions and walls: Square cornered tile wall boxes 3.5 inches (90 mm) deep, or four-inch (100-mm) square boxes with raised tile wall device covers. The device covers shall be of extra depths required to suit the block or brick construction in which they are placed.
- C. Switch and receptacle boxes in metal stud partitions: 4 inches (100 mm) square by 1.5 inches (38 mm) deep boxes with 0.75-inch (19-mm) raised tile wall device covers finishing flush with finished wall surface.
- D. Wall- and partition-mounted outlets for low-voltage systems: Same as specified above for switches and receptacles.

2.22 JUNCTION AND PULL BOXES

- A. Junction and pull boxes in feeder conduit runs: Galvanized, of size required for conduit arrangement and not less than the size required by NFPA 70, and furnished with screwed covers.

2.23 FLOOR BOXES

- A. Floor box for power and communications equal to Wiremold RFB Series, complete in-floor multi-service box consisting of floor box housing, flush removable cover, and wiring devices, as detailed on drawings.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Provide box at each outlet, switch, and appurtenance. Each box shall be of a type suitable for the duty intended and shall be installed in accordance with the manufacturer's instructions.
 - 1. Where conduit is weather-exposed or exposed, provide cast-steel or cast-aluminum boxes.
- B. Coordinate locations of boxes with installation of conduit as specified in Section 260533.
- C. Do not install boxes back-to-back (through the wall) in partitions.
- D. Firmly secure the boxes in place, plumb, level, and with front of device cover even with finished wall surface.
- E. Boxes in metal stud walls or partitions shall be securely supported by metal channels spanning between two studs and attached to same.
- F. Outlet boxes used for supporting lighting fixtures: Furnish with malleable iron fixture studs of "No-Bolt" type, secured by locknut. Provide structural channel supports for boxes occurring in ceilings. Outlets in ceilings directly on bottom of joists shall be supported independent of ceiling construction. Outlets in suspended ceilings shall not be supported from ceiling construction. Special supports for boxes shall be as directed and approved by the Architect.

- G. Where service fittings will not permit ganging of boxes for floor outlets, outlets shall be as close as practical.
- H. Provide poke-through service fittings where indicated.
 - 1. Install more than 2 feet apart, and not to exceed an average of one every 65 sq. ft.
 - 2. Core drill holes 4 inches in diameter.
- I. Provide a single cover plate where two or more devices are grouped together in one box.
- J. Verify door swings with door frame installed before locating switch outlets.
- K. Outlet boxes in fire-rated assembly:
 - 1. Clearance between boxes and wallboard shall not exceed 0.125 inch (3.2 mm).
 - 2. Surface area of individual outlet box does not exceed 16 square inches (103 sq cm).
 - 3. Entire surface area of boxes shall not exceed 100 square inches (645 sq cm) per 100 square feet (9.3 sq m) of wall surface.

3.59 IDENTIFICATION

- A. Identification on outside covers of pull and junction boxes in ceiling space or exposed on walls: Paint with colored enamel or mark with permanent waterproof black marker, or both, as specified.
 - 1. Fire alarm system: Red.
 - 2. Other special systems: Mark with system type, such as Data, Public Address, or Security.
 - 3. Power and lighting: Panelboard designation and circuit number(s).

END OF SECTION 260534

SECTION 260536 - CABLE TRAY

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Cable tray system.
 - 1. Ladder type.
 - 2. Wire mesh type.
 - 3. Cable tray accessories.

1.14 RELATED SECTIONS

- A. Firestopping: Section 260507.
- B. Voice and data systems: Division 27.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data: Cable tray and accessories.
 - 1. Include data indicating finishes and dimensions for each type of cable tray.
- C. Shop drawings: For each type of cable tray.
 - 1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.

1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 260500, Common Work Results for Electrical.
- B. Cable tray shall be manufactured by a company regularly engaged in the manufacture of metal cable trays and a member of NEMA. Trays shall conform to NEMA Metal Cable Tray Standard Publication VE-1. All cable trays and components shall be from a single manufacturer.
- C. Manufacturer shall provide test reports witnessed by an independent testing laboratory of the "worst case" loading conditions outlined in this specification and performed in accordance with the latest revision of NEMA VE-1.

PART 2 - PRODUCTS

2.01 CABLE TRAY

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified T.J Cope/Atkore International product, or comparable product by one of the following:
 - 1. Eaton B-Line, Inc.

2. Cope/Atkore International
3. Chalfant Manufacturing Company
4. Mono-Systems, Inc.
5. Cabo-fil, Legrand

2.20 LADDER CABLE TRAY

A. Description:

1. Configuration: Two longitudinal side rails with transverse rungs swaged or welded to side rails, complying with NEMA VE 1.
2. Width: 12 inches (300 mm) unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: 4 inches (100 mm).
4. Straight Section Lengths: 10 feet (3.0 m), except where shorter lengths are required to facilitate tray assembly.
5. Rung Spacing: 9 inches (225 mm).
6. Minimum Cable-Bearing Surface for Rungs: 7/8-inch (22-mm) width with radius edges.
7. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb (90-kg) concentrated load, when tested according to NEMA VE 1.
8. Fitting Minimum Radius: 12 inches (300 mm).
9. Class Designation: Comply with NEMA VE 1, Class 10A.
10. Splicing Assemblies: Bolted type using serrated flange locknuts.
11. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
12. Covers: Solid type made of same materials and with same finishes as cable tray.

B. Materials and Finishes:

1. Steel:
 - a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A 1008/A 1008M, Grade 33, Type 2.
 - b. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
 - c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
 - d. Finish: Hot-dipped galvanized after fabrication, complying with ASTM A123/A123 M, Class B2.
 - e. Hardware: Galvanized, ASTM B 633.
2. Aluminum:
 - a. Materials: Alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and Alloy 5052-H32 according to ANSI H35.1/H 35.1M for fabricated parts.
 - b. Hardware: Chromium-zinc-plated steel, ASTM F 1136.

C. Hanger system: Trapeze channel and threaded rods.

1. Channel: Approximately 1.60 inches (4 cm) square and provided with appropriate fittings for attaching to the bottom of the cable tray and to the supporting rods.
2. Rods: Minimum 0.375-inch (9.5-mm) diameter with fittings to attach to the structure above.

2.21 WIRE MESH CABLE TRAY

A. Description:

1. Configuration: Galvanized-steel wire mesh, complying with NEMA VE 1.
2. Width: 12 inches (300 mm) unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: 4 inches (100 mm).
4. Straight Section Lengths: 10 feet (3.0 m), except where shorter lengths are required to facilitate tray assembly.
5. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb (90-kg) concentrated load, when tested according to NEMA VE 1.
6. Class Designation: Comply with NEMA VE 1, Class 8A.
7. Splicing Assemblies: Bolted type using serrated flange locknuts.
8. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

B. Materials and finishes:

1. Steel:
 - a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of ASTM A 1008/A 1008M, Grade 33, Type 2.
 - b. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
 - c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
 - d. Finish: Hot-dipped galvanized after fabrication, complying with ASTM A123/A123 M, Class B2.
 - e. Hardware: Galvanized, ASTM B 633.

C. Hanger system:

1. Wire basket supports shall be center support hangers, trapeze hangers, or wall brackets.
2. Trapeze hangers or center support hangers shall be supported by 0.25 inch or 0.375 inch diameter rods.

2.25 CABLE TRAY ACCESSORIES

- A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
- B. Barrier strips: Same materials and finishes as for cable tray.
- C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.90 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect cable trays according to NEMA VE1.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Provide a complete cable tray system as indicated and in accordance with recognized industry practices and NEMA VE-2, to ensure that the cable tray equipment complies with the requirements of NFPA 70 and applicable portions of NFPA 70B and NECA's "Standards of Installation" pertaining to general electrical installation practices.
- B. Coordinate cable tray with other electrical work as necessary to properly interface installation with other work.
- C. Provide sufficient space encompassing cable trays to permit access for installing and maintaining cables.
- D. Fasten cable tray supports to building structure.
- E. Place supports, so that spans do not exceed maximum spans on schedules, and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of tray rungs.
- F. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.
- G. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed recommended dimensions. Space connectors and set gaps according to applicable standard.
- H. Make changes in direction and elevation using manufacturer's recommended fittings.
- I. Make cable tray connections using manufacturer's recommended fittings.
- J. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 260507 "Firestopping for Electrical Work."

3.30 CABLE TRAY GROUNDING

- A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 260526 "Grounding and Bonding."
- B. Cable trays with electrical power conductors shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- C. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.40 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.

2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
4. Verify that there are no intruding items, such as pipes, hangers, or other equipment, in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. 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.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays.

3.61 TESTING

- A. Test cable tray support systems to ensure electrical continuity of bonding and grounding connections, and to demonstrate compliance with maximum grounding resistance. Maximum allowable resistance is 1 ohm. See NFPA 70B, Chapter 18, for testing and test methods.

END OF SECTION 260536

SECTION 260541 - LOW-VOLTAGE SERVICE ENTRANCE

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Service entrance for electric service, 277/480 V, 3 phase, 4 wires.
- B. Service entrance for communication services.
- C. Combined installation with natural gas service.

1.14 RELATED SECTIONS

- A. Temporary power for construction: Division 01.
- B. Trenching: Section 260501.
- C. Electrical underground ductbank: Section 260544.
- D. Equipment foundations: Section 260528.
- E. Natural gas service: Section 231123.

1.18 PAYMENT PROCEDURES

- A. New electric service will be installed by Baltimore Gas & Electric Co.
- B. Submit the bill on completion of this part of the work. Owner will directly pay the Power Company.

1.30 SUBMITTALS

- A. General: Submit in accordance with Division 01 and Section 260101.
- B. Product data: Each type of device or equipment required for the installation.
- C. Shop drawings: Submit shop drawings and other information as required to the Power Company.
- D. Certifications: Copy of certification for installation required by Power Company.

1.71 COORDINATION

- A. New electric service will be installed by Baltimore Gas & Electric Co. (the Power Company). Contact the designated power company service representative and verify the status of the project service application. If the current service application has expired, resubmit the service application using load data from the original application.
- B. New communications service(s) will be installed by the telephone company and the cable television company. Contact the service company representative(s) to coordinate installation of the new service(s).
- C. Arrange a project site meeting to verify that the proposed service entrance configurations are acceptable to the service company. Participants of the meeting shall include the service company representative, the Owner, the Contractor and the Architect.

- D. Contact "Miss Utility" (1-800-257-7777) prior to any excavation or underground work. The location and depth for all utilities shall be verified.

PART 2 - PRODUCTS

2.20 CONDUITS FITTINGS AND CONDUCTORS

- A. Power Company will provide primary and secondary cables, transformers, and meters, as described in the article "Installation by Power Company," below.
- B. Conduits: As specified and scheduled in Section 260533, Conduits.
- C. Ductbanks: As specified in Section 260544, Underground Ducts and Utility Structures, and in accordance with Power Company requirements.
- D. Fittings: As required by installation and by Power Company requirements, and as specified in Section 260533, Conduits.
- E. Cable for direct burial: Specified in Section 260519, Wires and Cables.

PART 3 - EXECUTION

3.05 PREPARATION

- A. Coordinate installation with Power Company.
- B. Coordinate installation with communications service company.
- C. Coordinate installation with installation of gas lines and other underground utilities specified in Divisions 23 and 31.

3.20 INSTALLATION BY POWER COMPANY

- A. Primary power from Power Company lines to a point underground at the property line.
- B. Primary and secondary cables, transformer and foundation, and terminations to building main switchboard, including meters.

3.21 INSTALLATION INCLUDED IN WORK OF THIS PROJECT

- A. Concrete encased ductbank from property line to power company transformer as indicated on the drawings, minimum 5 inches (127 mm), as specified in Section 260544, Underground Ducts and Utility Structures, including markers or underground warning tape and in accordance with Power Company requirements.
- B. Concrete encased ductbank from transformer to building as indicated on the drawings, minimum 4-inches (102 mm), as specified in Section 260544, Underground Ducts and Utility Structures, including markers or underground warning tape, and in accordance with Power Company requirements.

- C. Conduit from property line to building as shown on the drawings, minimum 4-inches (102 mm), as specified in Section 260544, Underground Ducts and Utility Structures, including markers or underground warning tape and in accordance with communications service company's requirements.
- D. Where conduit enters a transformer or meter cabinet, provide bellmouth fittings on conduit ends 2 inches (51 mm) above the concrete slab.
- E. Concrete foundation for Power Company transformer: Specified in Section 26 0528, Equipment Foundations.

3.22 TELEPHONE SERVICE INSTALLATION

- A. Provide conduit in ductbank for telephone service, as specified in Section 260544. Spacing between conduits shall be no less than 3 inches.

3.23 TELECOMMUNICATIONS SERVICES INSTALLATION

- A. Provide conduits in ductbank for telecommunications services, as specified in Section 260544. Spacing between conduits shall be no less than 3 inches.

END OF SECTION 260541

SECTION 260544 - UNDERGROUND DUCTS AND UTILITY STRUCTURES

PART 1 - GENERAL

1.10 SUMMARY

A. This section includes the following:

1. Ducts in directly buried duct banks.
2. Ducts in concrete-encased duct banks.
3. Handholes and handhole accessories.

1.20 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO-HB 17: Standard Specifications for Highway Bridges. Includes the AASHTO categories for structural loads:
 - a. Heavy traffic: HS20.
 - b. Medium traffic: HS15.
 - c. Light traffic: H10.

B. ASTM International (ASTM)

1. ASTM C 478: Precast Reinforced Concrete Manhole Sections.
2. ASTM C 857: Minimum Structural Design Loading for Underground Precast Concrete Utility Structures. Includes classes which correspond to AASHTO categories:
 - a. Heavy traffic: Class A-16.
 - b. Medium traffic: Class A-12.
 - c. Light traffic: Class A-8.
 - d. Walkway: Class A-0.3, 300 lb/sq ft (1465 kg/sq m).
3. ASTM C 858: Specification for Underground Precast Concrete Utility Structures.

C. Society of Cable Telecommunications Engineers (SCTE):

1. SCTE 77: Specification for Underground Enclosure Integrity. Light duty and pedestrian traffic only. Includes Tiers for specific applications, and static vertical wheel load ratings:
 - a. Tier 5: Sidewalk applications with a safety factor for occasional nondeliberate vehicular traffic.
 - b. Tier 8: Sidewalk applications with a safety factor for nondeliberate vehicular traffic.
 - c. Tier 15: Driveway, parking lot, and off-roadway applications subject to occasional nondeliberate heavy vehicular traffic.

1.30 SUBMITTALS

A. Product data: For the following:

1. Conduit and ducts, including elbows, bell ends, bends, fittings, and solvent cement.
2. Duct bank materials, including spacers and miscellaneous components.
3. Warning tape.

- B. Shop drawings: Show fabrication and installation details for underground ducts and utility structures and include the following:
 - 1. For precast handholes, shop drawings shall be signed and sealed by a qualified professional engineer, and shall show the following:
 - a. Construction of individual segments.
 - b. Joint details.
 - c. Design calculations.
- C. Coordination drawings: Show duct profiles and coordination with other utilities and underground structures. Include plans and sections drawn to scale, and show all bends and location of expansion fittings.
- D. Product test reports: Indicate compliance of manholes with ASTM C 857 and ASTM C 858, based on factory inspection.

1.40 QUALITY ASSURANCE

- A. Electrical components, devices, and accessories (including ducts for communications and telephone service): 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 ANSI C2.
- C. Comply with NFPA 70.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Deliver ducts to project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

1.60 PROJECT CONDITIONS

- A. 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 Architect at least two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Architect's written permission.

1.71 COORDINATION

- A. Coordinate layout and installation of ducts and handholes with final arrangement of other utilities and site grading, as determined in the field.
- B. Coordinate elevations of ducts and duct bank entrances into handholes with final profiles of conduits as determined by coordination with other utilities and underground obstructions. Revise locations and elevations from those indicated as required to suit field conditions and to ensure duct runs drain to handholes, and as approved by Architect.

1.91 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.

PART 2 - PRODUCTS

2.01 PRODUCTS AND 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. Nonmetallic ducts and accessories:

- a. ARNCO Corp.
- b. Beck Manufacturing Inc.
- c. Cantex, Inc.
- d. CertainTeed Corp.; Pipe & Plastics Group.
- e. ElecSys, Inc.
- f. Electri-Flex Co.
- g. IPEX, Inc.
- h. Lamson & Sessions; Carlon Electrical Products.
- i. Manhattan/CDT
- j. Spiraduct/AFC Cable Systems, Inc.

- 2. Precast polymer concrete enclosures for underground construction:

- a. Quazite/Strongwell (Hubbell Power Systems, Inc.).
- b. Synertech (Division of Oldcastle Precast).

2.20 CONDUIT

- A. Conduit and fittings are specified in Section 260533.

2.21 DUCTS

- A. Rigid nonmetallic conduit: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by the same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.
- B. Rigid nonmetallic conduit: NEMA TC 2, Type EPC-80-PVC, UL 651, with matching fittings by the same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.
- C. Plastic utilities duct: NEMA TC 6, Type EB-20-PVC, ASTM F 512, UL 651A, with matching fittings by the same manufacturer as the conduit, complying with NEMA TC 9.
- D. Reinforced fiberglass epoxy duct: Type FRE, NEMA TC-14A (IPS) medium wall, UL listed and meeting applicable ASTM standards for medium-voltage service.

2.22 HANDHOLES

- A. Cast-metal boxes: Cast aluminum, with outside flanges and recessed, gasketed cover for flush mounting and with nonskid finish and legend on cover. Unit, when buried, shall be designed to support AASHTO H10 loading.

- B. Polymer concrete handholes: Molded of sand and aggregate bound with polymer resin, and reinforced with steel, with 6-inch (150-mm) square cable entrance at each side and weatherproof cover with nonskid finish and legend. Unit, when buried, shall be designed to support SCTE 77 Tier 15 loading.
- C. Cover legend: "ELECTRIC" or "COMMUNICATIONS".

2.25 ACCESSORIES

- A. Duct spacers: Rigid, nonmetallic, horizontally and vertically interlocking spacers, selected to provide minimum duct spacings and cover depths indicated while supporting ducts during concreting and backfilling.
- B. Duct-sealing compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) without slump and of adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.
- C. Warning tape: Underground-line warning tape specified in Section 260553, Identification for Electrical Systems.

2.26 CONSTRUCTION MATERIALS

- A. Waterproofing: Comply with Division 07 section specifying waterproofing.
- B. Dampproofing: Comply with Division 07 section specifying dampproofing.
- C. Mortar: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. (60 L) where packaged mix complying with ASTM C 387, Type M, may be used.
- D. Concrete: Use 3000-psi- (20.7-MPa-) minimum, 28-day compressive strength and 0.375-inch (10-mm) maximum aggregate size. Concrete and reinforcement are specified in Division 03 Section "Cast-in-Place Concrete."

PART 3 - EXECUTION

3.20 APPLICATIONS

- A. Underground ducts for electrical cables higher than 600 V: Type EPC-40-PVC concrete-encased duct bank.
- B. Underground ducts for electrical feeders 600 V and below: Type EB-20-PVC or EPC-40-PVC, concrete-encased duct bank.
- C. Underground ducts for electrical branch circuits 600 V and below: Type EPC-40-PVC, directly buried duct bank, except use Type EPC-80-PVC when crossing roads.
- D. Underground ducts for telephone utility service: Type EPC-40-PVC, directly buried duct bank, except use Type EPC-80-PVC when crossing roads.
- E. Underground ducts for communication circuits: Type EPC-40-PVC, directly buried duct bank.
- F. Handholes: Underground precast polymer concrete enclosures.

3.21 EARTHWORK

- A. Excavation and backfill: Comply with Division 31 Section specifying Earthwork but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- C. Restore all areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Division 32 Section specifying Landscaping.
- D. Restore disturbed pavement. Refer to "Cutting and Patching" in Section 260101.

3.22 CONDUIT AND DUCT INSTALLATION

- A. Slope: Pitch ducts a minimum slope of 1:300 down toward handholes and away from buildings and equipment.
- B. Curves and bends: Use manufactured elbows for stub-ups at equipment and at building entrances. Use manufactured long sweep bends with a minimum radius of 25 feet (7.5 m), both horizontally and vertically, at other locations.
- C. Use solvent-cement joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in the same plane.
- D. Duct entrances to handholes: Space end bells approximately 10 inches (250 mm) o.c. for 5-inch (125-mm) ducts and vary proportionately for other duct sizes. Change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell without reducing duct line slope and without forming a trap in the line. Grout end bells into manhole walls from both sides to provide watertight entrances.
- E. Building entrances: Make a transition from underground duct to rigid steel conduit at least 10 feet (3 m) outside the building wall. Use fittings manufactured for this purpose. Follow the appropriate installation instructions below:
 - 1. Concrete-encased ducts: Install reinforcement in duct banks passing through disturbed earth near buildings and other excavations. Coordinate duct bank with structural design to support duct bank at wall without reducing structural or watertight integrity of building wall.
 - 2. Waterproofed wall and floor penetrations: Install a watertight entrance-sealing device with sealing gland assembly on the inside. Anchor device into masonry construction with one or more integral flanges. Secure membrane waterproofing to the device to make permanently watertight.
- F. Concrete-encased, nonmetallic ducts: Support ducts on duct spacers, spaced as recommended by manufacturer and coordinated with duct size, duct spacing, and outdoor temperature. Install as follows:
 - 1. Separator installation: Space separators close enough to prevent sagging and deforming of ducts and secure separators to earth and to ducts to prevent floating during concreting. Stagger spacers approximately 6 inches (150 mm) between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.

2. **Concreting:** Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct bank application. Pour each run of envelope between manholes or other terminations in one continuous operation. If more than one pour is necessary, terminate each pour in a vertical plane and install 0.75-inch (19-mm) reinforcing rod dowels extending 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.
 3. **Reinforcement:** Reinforce duct banks where they cross disturbed earth and where indicated.
 4. **Forms:** Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
 5. **Minimum clearances between ducts:** 3 inches (75 mm) between ducts and exterior envelope wall, 2 inches (50 mm) between ducts for like services, and 4 inches (100 mm) between power and signal ducts.
 6. **Depth:** Install top of duct bank at least 24 inches (600 mm) below finished grade in nontraffic areas and at least 30 inches (750 mm) below finished grade in vehicular traffic areas, unless otherwise indicated.
- G. **Directly buried ducts:** Support ducts on duct spacers, spaced as recommended by manufacturer and coordinated with duct size, duct spacing, and outdoor temperature. Install as follows:
1. **Separator installation:** Space separators close enough to prevent sagging and deforming of ducts.
 2. **Install expansion fittings** as shown on shop drawings.
 3. **Trench bottom:** Continuous, firm, and uniform support for duct bank. Prepare trench bottoms as specified in Division 31 Section specifying earthwork.
 4. **Backfill:** Install backfill as specified in Division 31 Section specifying earthwork. After installing first tier of ducts, backfill and compact. Repeat backfilling after placing each tier. After placing last tier, hand-place backfill to 4 inches (100 mm) over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, complete backfilling normally.
 5. **Minimum clearances between ducts:** 3 inches (75 mm) between ducts for like services and 6 inches (150 mm) between power and signal ducts.
 6. **Depth:** Install top of duct bank at least 24 inches (600 mm) below finished grade, unless otherwise indicated.
- H. **Warning tape:** Bury warning tape approximately 12 inches (300 mm) above all concrete-encased duct banks. Align tape parallel to and within 3 inches (75 mm) of the centerline of duct bank.
- I. **Stub-ups:** Use rigid steel conduit for stub-ups to equipment. For equipment mounted on outdoor concrete bases, extend steel conduit a minimum of 5 feet (1.5 m) from edge of base. Install insulated grounding bushings on terminations. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches (75 mm) of concrete.
- J. **Sealing:** Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.
- K. **Pulling cord:** Install 100-lbf- (445-N-) test nylon cord in ducts, including spares.

3.60 FIELD QUALITY CONTROL

- A. Testing: Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
- B. Duct integrity: Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of the duct. If obstructions are indicated, remove obstructions and retest.
- C. Correct installations if possible and retest to demonstrate compliance. Remove and replace defective products and retest.

3.61 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

END OF SECTION 260544

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.10 SUMMARY

- A. This section includes electrical identification materials and devices required to comply with ANSI, NFPA, and OSHA standards.
- B. This section addresses identification of electrical equipment, raceways, boxes, conductors, and other related electrical system components.

1.11 SECTION INCLUDES

- A. Identification for raceways and cables.
- B. Identification of power conductors and control cables.
- C. Identification of equipment and instructions.
- D. Miscellaneous identification products.

1.14 RELATED SECTIONS

- A. Sections in Divisions 26, 27, and 28.

1.20 REFERENCES

- A. ANSI A13.1: Scheme for the Identification of Piping Systems.
- B. ANSI Z535.4: Standard for Product Safety Signs and Labels.
- C. ANSI/IEEE C2: National Electrical Safety Code.
- D. NFPA 70: National Electrical Code.
- E. NFPA 70E: Standard for Electrical Safety in the Workplace.
- F. OSHA 29 CFR 1910.144: Safety Color Code for Marking Physical Hazards.
- G. OSHA 29 CFR 1910.145: Specifications for Accident Prevention Signs and Tags.
- H. UL 969: Standard for Marking and Labeling Systems.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data: For each type of electrical identification product.

1.40 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and IEEE C2.

- B. Comply with NFPA 70.
- C. Comply with OSHA standards.
- 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.

1.49 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in other sections requiring identification applications, drawings, shop drawings, manufacturer's wiring diagrams, and the operation and maintenance manual; and with those required by codes, standards, and safety regulations. Use consistent designations throughout Project.
- B. Coordinate installation of identification materials and devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identification materials and devices with location of access panels and doors.
- D. Install identifying materials and devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following manufacturers, or approved equal:
 - 1. Brady USA, Inc.
 - 2. Carlton Industries
 - 3. Graphic Products, Inc.
 - 4. Ideal Industries, Inc.
 - 5. Panduit Corporation
 - 6. Presco
 - 7. Seton Identification Products
 - 8. Thomas and Betts Company
 - 9. Utility Safeguard

2.10 GENERAL PRODUCT REQUIREMENTS

- A. Except where otherwise indicated, provide manufacturer's standard identification products of category and type suitable for each application. Where more than one identification method is specified for an application, the Installer shall select and utilize each material in a consistent manner.

2.11 RACEWAY IDENTIFICATION

- A. Comply with ANSI A13.1 for minimum lettering size, length of color field, and coloring schemes for each raceway size, type, and location.

1. Colors: Black letters on Orange field.
2. Legend: Raceways carrying the following:
 - a. Power circuits less than 600V: Indicate system voltage.
 - b. Low-voltage systems less than 50V: Indicate system type (Example – “TELECOMMUNICATIONS”).

- B. Adhesive labels: Preprinted, flexible, self-adhesive vinyl with legend overlaminated with a clear weather- and chemical-resistant coating.

2.12 CONDUCTOR AND CABLING IDENTIFICATION

- A. Color-coded, adhesive tape: Self-adhesive, vinyl tape, in appropriate colors for system voltage and phase.

2.13 EQUIPMENT IDENTIFICATION

- A. Engraved plastic nameplates: Laminated plastic, engraved, white letters on black background, except where other color schemes are noted or specified.
 1. Size: Minimum 0.75-inch (19 mm) by 2.5-inches (64 mm).
 2. Letter size: Minimum height of 0.375-inch (10 mm).
 3. Mechanically fastened, except adhesive mounted where necessary due to substrate.
 - a. Mechanical fastener: Punched or drilled, with vandalproof stainless steel or brass screws or rivets.
- B. Baked-enamel signs: Preprinted, aluminum signs, punched or drilled for fasteners with corner grommets; with colors, legend, and size required for application.
- C. Exterior, metal-backed, signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate (CAB) signs with galvanized steel backing; punched or drilled for fasteners with corner grommets; with colors, legend, and size required for application.
- D. Adhesive film label: Machine-printed, black letters on white background, through thermal transfer or equivalent process, with clear weatherproof and UV-resistant covering. Minimum letter size height of 0.375-inch (10 mm).

2.14 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Underground warning tape: Permanent, bright-colored, continuous-printed, vinyl tape for use with underground cables, conduits, and ductbanks. Comply with ANSI Z535.
 1. Not less than 6-inches wide by 4 mils thick (152 mm wide by 0.102 mm thick).
 2. Tape Material:
 - a. Made of metal detectable polyester or vinyl.
 - b. Compounded for permanent direct-burial service. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to destructive substances commonly found in soils.
 3. Printed legend with black lettering, indicating type of underground line.

- a. Provide inscriptions for power cabling with red-colored tape: Example – “CAUTION – BURIED ELECTRIC LINE BELOW”.
 - b. Provide inscriptions for low-voltage system cabling with orange-colored tape: Example – “CAUTION – BURIED FIBER OPTIC LINE BELOW”.
- B. Wiring device tape labels:
1. Adhesive film label: Machine-printed, black letters on clear background, through thermal transfer or equivalent process. Minimum letter size height of 0.25-inch (6 mm).
 - a. Labeling for electrical devices and components such as receptacles, switches, control device stations, manual motor starters, network and phone jacks, junction and pull boxes, etc.
- C. Warning labels and signs:
1. Self-adhesive warning labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise noted.
 2. Baked-enamel warning signs: Preprinted, aluminum signs, punched or drilled for fasteners with corner grommets; with colors, legend, and size required for application.
 3. Fasteners: Self-tapping, stainless-steel screws or, stainless-steel machine screws with nuts, flat and lock washers.
- D. Tape markers: Vinyl, pressure-sensitive, with clear vinyl overlay.
1. Working space, floor markers: Minimum 2-inch (50 mm) wide, 5 mil (0.125 mm) thick, with black and yellow stripes.
- E. Adhesive: Heavy-duty, thermo-resistant, industrial grade adhesive, for adhesion to any surface without identification curling, peeling, or falling off.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification products at locations for most convenient viewing without interference with operation and maintenance of equipment.
 1. For finished public spaces, coordinate identification product mounting locations with Architect.
- C. Apply identification products to surfaces after equipment finish work has been completed.
- D. Clean surfaces before applying identification products, using materials and methods recommended by manufacturer of identification device.
- E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

- F. System identification labeling for raceways and cables: Each label shall be installed on sidewall of conduit and easily placed for proper identification. Locate labels 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.
- G. System identification color-coding bands for raceways and cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands 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.
- H. Underground-line warning tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16-inches (400 mm) overall.

3.30 APPLICATION

A. Miscellaneous:

- 1. Access doors and panels: Apply engraved nameplate labels at access doors identifying concealed electrical item. Do not locate labels in finished, public spaces.
- 2. Arc flash warning labels: Refer to Section 260573, Overcurrent Protective Device Studies, for arc flash labeling requirements.

B. Junction and pull boxes:

- 1. Label each junction and pull box, identifying circuit designation or type of system.
 - a. Exposed boxes: Place label on coverplate, externally visible.
 - b. Concealed boxes: Place label or tag on inside cover of box.
 - c. Junction boxes concealed above suspended ceilings or exposed in non-occupied spaces may be marked with permanent ink marker in lieu of printed labels.
- 2. Boxes with conductors greater than 600V: Apply labels identifying nominal system voltage on cover and minimum of one fixed side. One label shall be visible from the floor where boxes are installed exposed.
- 3. Fire alarm system boxes shall have red finish. Boxes shall be prefinished prior to installation.

C. Raceway identification: Apply identification products for each raceway.

- 1. Apply color-coded identification products to raceways as follows:
 - a. Normal power system: None.
 - b. Standby/emergency power system: None.
 - c. Fire alarm system: Red, solid colored.
 - d. Telecommunications system: None color banded .
 - e. Security System: None.
- 2. Apply labels identifying nominal system voltage for the raceways containing feeders and raceways larger than 2-inch (53 mm) with power conductors. Labeling of raceways with branch circuit conductors is not required.
- 3. Apply system identification labels identifying type of system for low-voltage system raceways.

4. Apply circuit designation markings on each feeder and branch circuit raceway entering and leaving each panelboard and switchboard. Mark raceway clearly with permanent ink marker or printed labels.
5. Empty raceways: Apply labels indicating description of empty raceways (i.e., spare, future use) and identifying the beginning and end locations. Mark raceway clearly with permanent ink marker or printed labels.

D. Wiring and cabling identification:

1. Power circuit conductor identification, 600 V or less: Apply color-coded identification for cables, feeders, and power circuit conductors exposed in accessible vaults, junction and pull boxes, utility structures, and equipment enclosures. Apply color-coding scheme as indicated below throughout the building's network of feeders and circuits, unless otherwise required by the authority having jurisdiction.
 - a. Colors on conductors No. 10 and smaller, or No. 6 and smaller for grounded and grounding conductors: Solid colored insulation.
 - b. Colors on conductors No. 8 and larger, or No. 4 and larger for grounded and grounding conductors: Apply colored tape wrapped a minimum of 6 inches (150 mm) on either end of conductor and in boxes where splices or taps are made.
 - c. Conductors used solely for grounding purposes shall be green, if insulated.
 - d. Where multi-conductor cables are used, use same color coding system for identification of wiring.

COLOR CODE (600 V Max.)				
VOLTAGE	NEUTRAL	PHASE		
		A	B	C
120-V, 2-wire	White	Black, Red, or Blue depending on phase		
277-V, 2-wire	Gray	Brown, Orange, or Yellow depending on phase		
208/120-V wye, 3-phase, 4-wire	White	Black	Red	Blue
480/277-V wye, 3-phase, 4-wire	Gray	Brown	Orange	Yellow
480-V delta, 3-phase, 3-wire		Brown	Orange	Yellow

2. Conductors for future use: Attach tags with circuit designation for conductors to be extended for future use.
3. Control and low-voltage system wiring shall be coded with colors and markings different from those used to designate phase wires.

E. Wiring device labels: For wiring devices such as receptacles, devices installed in surface raceway assemblies, and other wiring devices operating at or greater than 120V.

1. Apply adhesive film labels on inside of wiring device coverplates identifying circuit designation serving device.
2. For special receptacle configurations, apply label identifying applicable device NEMA configuration designation in location not concealed by plug.
3. Apply labels to devices serving low-voltage system devices including the following:
 - a. Fire alarm devices and test stations: Circuit designation.
 - b. Telecommunications device stations: Work area outlet designation.
 - c. Audio-visual device stations: Device designation.
 - d. Security device stations: Device designation.

F. Equipment Identification: Install unique designation label consistent with contract documents and shop drawings.

1. Labeling instructions:
 - a. Engraved plastic laminate nameplates, unless otherwise indicated.
 - b. Unless otherwise required, provide a single line of text with 0.5-inch (13 mm) high lettering on 1.5-inch (38 mm) high label. Where two or more lines are required, use single label with increased height.
 - c. For multi-section or multi-compartment equipment, apply labels identifying each compartment or section.
 - d. For fusible equipment, identify fuse type and size on the front cover.
 - e. For enclosed circuit breaker equipment, identify device trip rating where rating is not visible.
 - f. Where equipment has more than one source of power (i.e., transfer switch, separate control power source), the location and circuit designation of each power source shall be clearly identified at the equipment location.

2. Apply nameplates and labels to equipment according to the below identification schemes:
 - a. Identify equipment designation; voltage rating; phase and number of wires; and designation and location of load served. Apply products to the following equipment:
 - (1) Panelboards
 - (2) Switchboards
 - (3) Dimming system equipment

 - b. Identify equipment designation; primary and secondary voltage ratings; phase and number of wires; circuit designation and location of primary source; and designation and location of load served. Apply products to the following equipment:
 - (1) Disconnect switches
 - (2) Enclosed circuit breakers
 - (3) Contactors
 - (4) Motor starters and combination motor starter-disconnects
 - (5) Variable frequency drives
 - (6) Transformers
 - (7) UPS equipment

 - c. Identify equipment designation; voltage rating; phase and number of wires; and capacity rating. Apply products to the following equipment:
 - (1) Generator: Capacity rating in kilo-watts (kW).
 - (2) Transfer switches: Capacity rating in amperes; identify the location and circuit designation of each power source at the equipment location.

 - d. Identify equipment designation; and circuit designation and location of primary source. Apply products to the following equipment:
 - (1) Monitoring and control equipment
 - (2) Control stations
 - (3) Fire alarm control panels and auxiliary equipment
 - (4) Security panels and auxiliary equipment

- G. Working space requirements: Identify required working clearances at electrical equipment. Working clearance dimensions shall be in compliance with NFPA 70 and OSHA regulations.

1. Working space labels, markers, and signs: Apply permanent labels, markers, or signs at the following locations with appropriate message indicating required working clearances.
 - a. Apply identification products to electrical equipment installed in unfinished spaces such as mechanical, electrical, and storage rooms. Do not install identification products at equipment installed in finished or public spaces unless otherwise indicated.
 - b. Apply floor marking tape or paint on the floor in mechanical rooms and storage rooms to clearly show required working clearances.
 - c. Electrical distribution equipment including the following: Switchboards, panelboards, transformers, enclosed circuit breakers, disconnect switches, and motor controllers.

H. Warning and caution labels and signs:

1. Apply warning and caution labels on equipment in accordance with NFPA 70 and 70E, ANSI, and OSHA requirements including arc-flash hazard warning labels and special clearance requirements.
2. Apply warning and caution labels and signs at locations where safe operation and maintenance of electrical system equipment is of concern.
3. Apply warning signs on electrical room doors in accordance with NFPA 70 and 70E, ANSI, and OSHA requirements. Where doors are located in finished, public areas, located sign on the inside of the door. Coordinate mounting requirements with door type.

I. Service-entrance equipment: Provide field marking of service entrance equipment maximum available fault current values in accordance with NFPA 70 requirements.

J. Underground Warning Tape: Apply underground warning tape above underground ductbanks, conduit, or direct-buried cable.

K. Operating instruction signs:

1. Apply instruction signs at locations where directions for safe operation and maintenance of electrical system equipment are necessary. Apply approved text where instructions are needed for proper system operation.
 - a. Emergency instructions: Provide white text on red background.

3.60 FIELD QUALITY CONTROL

- A. Coordinate names, abbreviations, colors, and other designations with construction documents, submittals, and applicable code and standards requirements. Utilize consistent designations and identification techniques throughout project.
- B. Install identification products at locations that are clearly visible at normal viewing angles and without interference with operation and maintenance of the equipment.
- C. Install identification products in a neat and clean, workmanship-like manner where products are securely attached and oriented parallel to equipment edges.

END OF SECTION 260553

SECTION 260573 - OVERCURRENT PROTECTIVE DEVICE STUDIES

PART 1 - GENERAL

1.11 SECTION INCLUDES

A. Electrical system fault-current and protective device study:

1. Fault-current analysis.
2. Coordination study and device settings.
3. Arc-flash hazard analysis.

1.20 REFERENCES

A. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems.
2. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings.
3. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
4. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis.
5. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.
6. IEEE 1584 - Guide for Performing Arc-Flash Hazard Calculations.

B. American National Standards Institute (ANSI):

1. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
2. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures.
3. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
4. ANSI C37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories.

C. National Fire Protection Association (NFPA):

1. NFPA 70 – National Electrical Code, latest edition.
2. NFPA 70E – Standard for Electrical Safety in the Workplace.

D. Occupational Safety and Health Administration (OSHA):

1. OSHA 29 Code of Federal Regulations (CFR) Part 1910, Subpart S.

1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 260101.

B. Product data: For computer software to be used to perform studies.

C. Product certificates: For coordination-study and fault-current analysis computer software programs, certifying compliance with IEEE 399.

D. Qualifications:

1. Submit evidence indicating individual and organization compliance with requirements indicated in "Quality Assurance" below.

E. Preliminary electrical system study: Submit for review before distribution equipment shop drawings have been submitted, and before equipment order has been released to the manufacturer.

1. If formal completion of the study may delay the project schedule, Architect/Engineer may approve use of the preliminary draft for ordering equipment.
2. If approved for use in ordering equipment, preliminary draft shall include sufficient study data to ensure that the selection of device ratings and characteristics will be satisfactory.

F. Final electrical system study:

1. Submit final report for review and record.
2. Incorporate changes resulting from deficiencies and corrections of preliminary draft report.

G. Reports:

1. Electrical system study report: Submit reports required above including the following items:
 - a. General report information: Scope, definitions, descriptions, assumptions, and other information necessary to properly interpret results of the report.
 - b. Tabulated summary comparing protective device ratings and calculated available fault-current levels.
 - c. Tabulated summary of protective device settings including circuit breaker, fuse, and relays.
 - d. Fault-current analysis calculations.
 - e. Selective coordination study overlay, plots of device time-current curves and relationship to other distribution system components.
 - f. Arc-flash hazard calculations including details of the incident energy and flash protection boundary calculations.
 - g. Recommendations for system improvements.
 - h. System one-line diagram.
 - i. Input and output data used for each component and for study calculations.
2. Submit final reports as electronic files in portable document format (.pdf) to Owner. Submit program base files in file format compatible with software utilized by Owner.

1.40 QUALITY ASSURANCE

- A. Electrical system study shall be performed by one or more independent qualified organizations, and under the supervision and approval of a Registered Professional Engineer skilled in performing and interpreting the power system studies.
- B. Qualifications of organization performing electrical system study: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices:
 1. Registered Professional Engineer shall be a full-time employee of the equipment manufacturer or of an approved engineering firm.

- 2. Registered Professional Engineer shall have a minimum of five (5) years of experience in performing power system studies and registered in the state where the project is located.
- C. Qualifications of computer based software: Widely available, complying with standards, guides, and codes as referenced above.
- D. Comply with IEEE 399 for general study procedures.
- E. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Computer software: Subject to compliance with requirements, utilize product by one of the following:
 - 1. EDSA Micro Corporation
 - 2. Operation Technology, Inc.
 - 3. SKM Systems Analysis, Inc. (Basis of Design)

2.20 COMPUTER SOFTWARE REQUIREMENTS

- A. Comply with IEEE 399.
- B. Computer software program shall be capable of performing fault-current analysis of project electrical distribution system.
- C. Computer software program shall be capable of plotting and diagramming time-current characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.
- D. Computer software program shall be capable of performing arc fault hazard analysis using equations as established by IEEE 1584 and requirements presented in NFPA 70E, Annex D.
- E. Software shall include a comprehensive equipment library of manufacturer-based and IEEE / ANSI based equipment to accurately model the electrical distribution system.

PART 3 - EXECUTION

3.02 EXAMINATION

- A. Examine project submittals for compliance with electrical distribution system requirements outlined on the drawings and in electrical specification sections.

3.20 SYSTEM DATA COLLECTION

- A. The Contractor shall furnish all data required to perform the power system studies. The Engineer performing the fault analysis, protective device coordination, and arc flash hazard analysis studies shall furnish the Contractor with a listing of required data immediately after award of the contract. The Contractor shall expedite collection of the data to ensure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.

- B. If applicable, include fault contribution of existing motors and equipment in the study. The Contractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.
- C. The Engineer performing the studies shall gather and tabulate input data necessary to support each study including the following:
 - 1. Product data for each component of the electrical distribution system.
 - 2. Utility available fault contribution and impedance values.
 - 3. Drawings, one-line, and riser diagrams showing system configuration, equipment designations, feeder lengths, and other applicable system characteristics.

3.21 SYSTEM FAULT CURRENT ANALYSIS

- A. Calculate the maximum available short-circuit momentary current and interrupting duties in amperes rms symmetrical for electrical power distribution system components. The calculation shall be performed for current immediately after initiation and for a three-phase bolted fault at each of the following locations:
 - 1. Electric utility's supply termination.
 - 2. Switchboards.
 - 3. Distribution panelboards.
 - 4. Branch circuit panelboards.
 - 5. Generator output terminals.
 - 6. Automatic transfer switch terminals.
- B. Study the project's electrical distribution system from normal and alternate power sources throughout electrical distribution system. Where system configuration allows multiple switching and operation arrangements through paralleled sources, include study that results in maximum fault conditions.
- C. For grounded systems, provide a line-to-ground fault current values for areas as defined above for the three-phase, bolted fault, short-circuit study.
- D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 141, IEEE 241, and IEEE 242.
- E. Study Report:
 - 1. Input data: Gather and provide the following input data, in tabular or graphic form, used to perform fault calculations and other studies in this section.
 - a. Utility three-phase and line-to-ground available contribution with associated X/R ratios.
 - b. Short-circuit reactance of rotating machines with associated X/R ratios.
 - c. Cable type, construction, size, quantity per phase, length, impedance and conduit type.
 - d. Transformer primary & secondary voltages, winding configurations, kVA rating, impedance, and X/R ratio.
 - e. Reactor inductance and continuous ampere rating.
 - f. Circuit breaker types and sizes.
 - 2. Methods and assumptions: Indicate calculation methods and assumptions that may have been used to perform analysis.

3. Results: Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram. Provide the following in a table format:
 - a. Source fault impedance and generator contributions
 - b. X/R ratios
 - c. Asymmetry factors
 - d. Motor contributions
 - e. Short circuit KVA
 - f. Symmetrical and asymmetrical fault currents
4. Equipment evaluation and conclusions:
 - a. Verify interrupting ratings and withstand ratings are equal to or higher than calculated fault current levels.
 - b. Verify adequacy of phase conductors at maximum three-phase, bolted fault currents.
 - c. Verify adequacy of equipment grounding conductors and grounding electrode conductors for grounded systems at maximum ground-fault currents.
5. Recommendations: List recommendations for equipment with inadequate ratings. Notify Architect in writing of existing equipment improperly rated for the calculated available fault current of the system.

3.22 SYSTEM COORDINATION STUDY

- A. Perform coordination study using approved computer software program. Prepare a written and graphical report using results of fault current study and proposed protective devices and system distribution components. Comply with IEEE 399.
- B. Coordination curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series using time-current curves plotted on log-log scale graphs.
- C. Prepare separate sets of curves to demonstrate full system coordination. Include the following equipment on plotted coordination curves:
 1. Electric utility's overcurrent protective devices.
 2. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
 3. Low-voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands.
 4. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
 5. Conductor damage curves.
 6. Ground-fault protective devices.
 7. Significant motor starting characteristics and motor damage points.
 8. Significant generator short-circuit decrement curve and generator damage point.
 9. Largest feeder circuit breaker for motor control center and distribution panelboards.
 10. Largest feeder circuit breaker for 208 volt panelboards on secondary side of 480 volt: 120/208 volt transformer.
- D. Recommended device settings: Prepare a tabulated summary of recommended device settings for system adjustable protective devices. Include the following information:
 1. Device tags.
 2. Circuit breakers:

- a. Sensor and plug ratings, where applicable.
 - b. Adjustable pickups and time delays (long time, short time, ground)
 - c. Adjustable time-current characteristic
 - d. Adjustable instantaneous pickup
 - e. Recommendations for improved system coordination
3. Fuses:
- a. Current rating
 - b. Type

3.23 SYSTEM ARC FLASH HAZARD ANALYSIS

- A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA 70E, Annex D.
- B. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (such as switchgear and panelboard) where work could be performed on energized parts.
- C. The arc-flash hazard analysis shall include electrical equipment locations where work such as examination, adjustment, service, or maintenance could be performed on energized parts.
- D. Safe working distances shall be based upon the calculated arc flash boundary considering incident energy of 1.2 cal/cm².
- E. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.
- F. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off).
 - 1. Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable.
- G. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators should be decremented as follows:
 - 1. Fault contribution from induction motors should not be considered beyond 3-5 cycles.
 - 2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g. contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).

- H. For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.
- I. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.
- J. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.
- K. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.
- L. Incident energy and flash protection boundary calculations:
 - 1. Arcing fault magnitude
 - 2. Device clearing time
 - 3. Duration of arc
 - 4. Arc flash boundary
 - 5. Working distance
 - 6. Incident energy
 - 7. Hazard Risk Category
 - 8. Recommendations for arc flash energy reduction

3.35 ARC FLASH WARNING LABELS

- A. The Contractor and organization performing the Arc Flash Hazard Analysis shall provide a 3.5 in. x 5 in. thermal transfer type label of high adhesion polyester for each work location analyzed.
- B. All labels will be based on recommended overcurrent device settings and will be provided after the results of the analysis have been presented to the owner and after any system changes, upgrades or modifications have been incorporated in the system.
- C. The label shall include the following information, at a minimum:
 - 1. Location designation
 - 2. Nominal voltage
 - 3. Flash protection boundary
 - 4. Hazard risk category
 - 5. Incident energy
 - 6. Working distance
 - 7. Engineering report number, revision number and issue date
- D. Labels shall be machine printed, with no field markings.
- E. Labels shall be in compliance with NFPA 70E and OSHA standards.
- F. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.

1. For each 600V, 480V, and applicable 208V panelboard, one arc flash label shall be provided.
2. For each motor control center, one arc flash label shall be provided.
3. For each low-voltage switchboard, one arc flash label shall be provided.
4. For each switchgear, one flash label shall be provided.
5. For medium voltage switches one arc flash label shall be provided.

3.60 FIELD QUALITY CONTROL

- A. Field Adjustment: Adjust relay and protective device settings according to the recommended settings table provided by the coordination study. Field adjustments to be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.
- B. Make modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.
- C. Notify Architect in writing of any required equipment modifications.

END OF SECTION 260573

SECTION 260800 - COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1. GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 and other applicable Sections, apply to Work of this Section. Failure to meet Cx requirements and failure to correct noncompliance and/or deficiencies subjects the Contractor to withholding of payments and completion. See General Conditions.
- B. Section 01 40 00 "Quality Requirements" Section- the Cx Plan shall apply to Work of this Section and must be properly coordinated. The Contractor shall satisfy all requirements of this Section and of the Cx Plan. In the event of conflict, the requirement that is considered most stringent by the Owner shall be considered in force.
- C. Section 26 05 00 "Electrical General Provisions" shall be made an integral part of this Section.
- D. Individual Division 26 Sections: Individual Sections which stipulate installation, startup, warranty and training requirements for the system or device specified in the Section.
- E. Commissioning Plan (Cx Plan) – Stipulates the relationships between the parties involved with the Cx process. Defines the milestones in completion incorporating the Cx process.
- F. Division 01 "Submittal Procedures": Stipulates additional copies of submittals to be submitted and refers to other sections for additional submittal requirements related to Cx.
- G. Division 01 "Closeout Procedures: Provides general requirements and specifications for O&M Documentation for Work across all Divisions.
- H. Section 220800 – Commissioning of Plumbing Systems: Section stipulates detailed requirements of Cx for all applicable plumbing systems.
- I. Section 230800 – Commissioning of Mechanical Systems: Section stipulates detailed requirements of Cx for all applicable electrical systems.

1.2 REFERENCE STANDARDS

- A. ASHRAE Guideline 1.1-2007, The HVAC Commissioning Process, American Society of Heating Refrigeration, and Air Conditioning Engineers, Atlanta, GA. www.ashrae.org
- B. ASHRAE Guideline 4-2008, Preparation of Operating and Maintenance Documentation for Building Systems, American Society of Heating Refrigeration, and Air Conditioning Engineers, Atlanta, GA. www.ashrae.org

1.3 SUMMARY

- A. Commissioning (Cx) is a systematic process of ensuring that building systems perform interactively according to the design intent and the owner's operational needs. For purposes of this project, the Cx process occurs during the construction, acceptance, and early occupancy phases. The objectives of this Cx process are as follows:

1. Ensure that installed systems are operable and maintainable.

2. Maintain a high level of quality assurance.
3. Test and verify the applicable heating, ventilating, and air conditioning (HVAC) and automatic temperature control (ATC) systems to ensure they are interacting and performing optimally.
4. Ensure proper documentation of the Cx process including meeting minutes, equipment start-ups, pre-functional checklists (PFC), and functional performance tests (FPTs). (Responsible party for completing specific documentation is outlined in Cx responsibilities section.)
5. Identify, track, record, and report all system and equipment deficiencies in the Cx Issues Log.
6. Provide technical expertise for the correction of deficiencies.
7. Ensure O&M documentation delivered to Owner is complete.
8. Document warranty start and end dates.
9. Meet or exceed all the Cx requirements for “Fundamental Commissioning” and “Enhanced Commissioning” as outlined in EA Prerequisite 1 and EA Credit 3, LEED New Construction Version 2.2.

1.4 DEFINITIONS AND ABBREVIATIONS

- A. Refer to the Cx Plan for additional definitions and abbreviations related to the Cx process.
- B. Commissioning Agent (CxA): Independent firm retained by the Owner to conduct the Cx Program. The CxA shall work with the various subcontractors, the Architect, and the Engineer-of-Record (EOR) to direct and oversee the Cx process and perform Functional Performance Testing (FPT).
- C. Commissioning Milestones: Cx Milestones are scheduled events that mark defining progress completion points in the execution of the Cx process. Cx Milestones include specific Meetings and Training Events as defined in the Cx Plan. Regularly scheduled construction progress or working meetings are not considered Cx Milestones.
- D. Commissioning Plan (Cx Plan): The Cx Plan outlines the entire Cx process in detail. The Cx Plan is part of the Contract Documents and outlines many of responsibilities, procedures and tasks throughout the Cx process from Design through Occupancy. It also indicates the details of the FPT that the Construction Manager (CM) and associated Contractors must participate in. The Cx Plan provides a detailed description of the work required by the CxA. Further, it is imperative that the CM and all associated Contractors read and understand the implications and procedures outlined in the Cx Plan prior to submitting their bid for the Work.
- E. Commissioning Program: This is a general reference to the entire Cx process and associated documents. The Cx process refers to all work
- F. Commissioning Team: The group of individuals who will collaborate to ensure the facility is fully and completely commissioned. The Cx Team will generally include a core group of individuals involved with all systems. This core group shall include the CxA, the GC, the Owner, and Owner’s Construction Manager (if applicable). On any given system, the team will also include the member of the contractor(s) responsible for the systems or equipment.
- G. Functional Performance Test(ing) (FPT): The detailed and thorough testing of the building systems and their interactions with the building components and other building systems to ensure they are operating in accordance with the final design intent. Testing is performed in various modes of operation and conditions. Both component performance and environmental design objectives will be monitored during this testing. Functional Performance Tests (FPTs) are tests developed by the CxA with input from appropriate Cx Team members that, when passed, indicate Functional Completion of the system or equipment.

1.5 COMMISSIONING TEAM

- A. The CxA shall designate a Commissioning Team (Cx Team) consisting of all members needed to execute the approved Cx Program. Definitions of these Parties are provided in the Cx Plan. Minimum Cx Team participation shall include:

1. CxA
2. Owner's Representatives (Owner)
3. Controls Contractor (CC)
4. Mechanical Contractor (MC)
5. Plumbing Contractor (MC)
6. Electrical Contractor (EC)
7. Architect

PART 2. PRODUCTS (NOT USED)

PART 3. EXECUTION

3.1 COMMISSIONED SYSTEMS

- A. The following mechanical systems, equipment and components will be commissioned by Premier Energy Services, LLC, the CxA under this project. Where applicable, sampling may be used to test the equipment listed below. Refer to the Cx Plan for sampling rates. This would allow for a representative portion of the equipment to be tested and not every unit. All general references to the equipment in this document refer only to equipment that shall be commissioned.

1. Lighting and Lighting Control
2. Emergency and Standby Power

3.2 COMMISSIONING MILESTONES AND PARTICIPANTS

- A. The following are the Cx Milestones (Cx-specific meetings and training events) required under this Contract. Complete descriptions, including Schedule and Attendees, are provided in the Cx Plan. They are provided here as a summary for the Contractor and associated Contractors. These Milestones are in addition to regular construction progress meetings and FPTs that are scheduled as systems and equipment are ready for testing.
1. Construction Phase Commissioning Scoping Meeting. Required Attendees include the CxA (lead), Construction Manager (CM), and Mechanical, Electrical, and Controls Contractors. Other required attendees include Owner Representatives, EOR, and Architect.
 2. Commissioning Progress Meetings. Required Attendees include the CxA (lead), CM, and Mechanical, Electrical, and Controls Contractors. Other required attendees include Owner Representative, and Tab Contractor.
 3. Maintenance Orientation and Inspection Meeting – 1. Required Attendees include the Mechanical Contractor (lead), CxA (assist), Electrical and Controls Contractors. Other required attendees include EOR, CM, Owner Representatives, and Architect.
 4. Maintenance Orientation and Inspection Meeting – 2. Required Attendees include the Mechanical Contractor (lead), CxA (assist), Electrical and Controls Contractors. Other required attendees include EOR, CM, Owner Representatives, and Architect.
 5. Owners Training of Cx Systems. Required Attendees include the CxA (lead), Construction Manager (CM), Owner Representatives and Operators. Applicable contractors and EOR may also be required.

6. Final Cx Meeting. Required Attendees include the CxA (lead), CM, and all Contractors involved in the Cx Team. Other required attendees include Owner Representatives, EOR, and Architect.

3.3 COMMISSIONING DOCUMENTATION

- A. The Design Phase Cx Plan is written by the CxA and included in the Contract Documents. The Plan shall be updated in accordance with the Cx Plan Progression Section in the Cx Plan.
- B. The Cx Issues Log shall be maintained by the CxA. It is used to track Cx-related issues or deficiencies found throughout the project. A sample Issues Log is included in the appendix of the Cx Plan. Refer to the Cx Documentation section in the Cx Plan for more information.
- C. CxA shall require Submittals relating to key systems or equipment from the Contractor as specified in the Cx Plan to ensure Owner's Requirements are met and facilitate the preparation of FPTs. Review is for Cx facilitation only and does not replace the Submittal Review of the Architect or EOR.
- D. The TAB Contractor is responsible for submitting a TAB Plan, in accordance with the Cx Plan, prior to beginning TAB of the building.
- E. The Controls Contractor (CC) is responsible for submitting a Controls Checkout Plan, in accordance with the Cx Plan, prior to beginning TAB of the building.
- F. The CxA will provide the Contractor with initial "generic" Pre-Functional Checklists. The Contractor is responsible for completing the Pre-Functional Checklists and Start-up Reports in accordance with the Cx Plan and other Contract Documents.
- G. The Contractor shall provide Trending Reports in tabular and graphical formats in accordance with the Cx Plan and Trending Request Forms prior to the start of the FPTs.
- H. The FPT procedures shall be developed by the CxA and provided to the Contractor for review prior to the start of the FPTs. Refer to the Cx Plan for additional information.
- I. The Contractor shall develop a Training Plan in accordance with the Cx Plan and other Contract Documents.
- J. The Contractor shall develop the Operation and Maintenance Manuals in accordance with the Cx Plan and other Contract Documents.

3.4 SEQUENCING AND SCHEDULING COMMISSIONING TASKS

- A. Contractor shall incorporate the Cx Program into the project schedule and timelines.
- B. Cx tasks to be separately indicated in the project schedule include but are not limited to:
 1. Start-Up: Indicate time required to properly perform Start-Up of each system and complete Start-Up Documentation.
 2. FPT: Indicate time required for FPTs, itemized as applicable for each system/area. Coordinate duration for the tasks with the CxA.

3.5 COMMISSIONING PROTOCOLS

- A. Coordination responsibilities and management protocols relative to Cx are initially defined in the Cx Plan and will be refined and documented at the Construction Phase Cx Scoping Coordination Meeting and also by scheduled updates to the Cx Plan. Contractor shall have input in the protocols and all Parties will commit to scheduling obligations. The CxA will record and distribute.

3.6 COMMISSIONING RESPONSIBILITIES

A. General

1. All parties involved in the design and construction of the facility bear responsibility in the Cx Program. The Cx Program does not fundamentally change the responsibilities of the team members from conventional projects carried out without a formal Cx Program. The Cx Program supplements and formalizes the responsibilities of all parties.
2. The role of the CxA is to oversee the Cx Program and to assist all other parties in achieving the goals of the project. Refer to the Cx Plan for further detail.
3. The Contractor (and associated Sub-Contractors) retains all responsibility for the installations. CxA inspections and tests will determine the adequacy and completeness of the installations to assist the Contractor in providing a sound installation. CxA testing does not alleviate the Contractor's responsibility for ensuring the systems are complete and functional throughout the Warranty Period.
4. Detailed responsibilities for the Mechanical Contractor and associated Sub-Contractors are indicated below. Refer to the Cx Plan for detailed responsibilities for other Contractors and Cx Team members. These responsibilities relate solely to the Cx Program and do not encompass all aspects of the project.
5. Some scopes or tasks indicated in the following list of responsibilities are further detailed in other subsections of the Cx Plan, including descriptions of meetings, training events, and required reports.

B. Electrical Contractor's (MC) Responsibilities

1. Attend Cx meetings, FPTs, and Training as outlined in the specifications, the Cx Plan, and as summarized in this subsection.
2. Include requirements for submittal data, including O&M data and training materials in each purchase order or sub-contract written. Provide submittals in electronic format originating from the manufacturer to ensure the highest resolution/quality.
3. Ensure cooperation of other Sub-Contractors as necessary.
4. Ensure cooperation and participation of specialty Sub-Contractors as necessary.
5. Ensure participation of major equipment manufacturers and their representatives as needed. Note all commissioned equipment that is standalone or provided with factory mounted controls will require the support of the start-up technicians during Cx FPTs.
6. Gather O&M data on all equipment, assemble electronically. Provide electronic manuals in accordance to Divisions 1, Section 26 2725, Basic Electrical Materials and Methods, and other related Sections. Submit to EOR after the equipment has been placed.
7. Attend Cx meetings and training events as outlined in the Cx Plan and other Contract documents.
8. Participate in and schedule vendors and Sub-Contractors to participate in the training sessions outlined in this plan and Contract Documents.
9. Prepare necessary preliminary schedule for O&M manual submission, training sessions, equipment start-ups, testing and job completion for use by the CxA. Update schedule as appropriate throughout the construction period.
10. Attend and participate in all CxA FPT's per the Cx Plan.

11. Provide all training in accordance with Contract Documents. Video tape training if required in the project specifications.
12. Assist the CxA in documentation and verification of equipment and system performance, including but not limited to FPTs. Schedule the Sub-Contractors (lighting control system representative) to assist during FPTs, as required.
13. Provide all tools and equipment necessary to perform FPTs, including those necessary for testing and operation of all Commissioned systems, as required by the CxA.
14. Turn over set of record mark-ups to the Electrical EOR for final incorporation into Record Documents.
15. The Electrical Contractor (EC) may be required for participation in start-ups of mechanical equipment, operation of electrical starters, breakers, etc., pre-functional checklists, and some aspects of the mechanical systems FPTs.
16. The appropriate Contractor or Manufacturer's Representative (in the case of factory testing and startup) shall provide written certification that the following work has been completed in accordance with the plans and specifications and that they are functioning as designed. Where the Work has been subcontracted, the Sub-Contractor shall be responsible for the initial certification with the primary Contractor re-certifying that he has inspected the Work and that it has been completed and functioning as designed. This certification must be submitted to the CxA prior to the final verification. Certifications are required for the following systems:
 - a. Indoor lighting and associated control systems.

C. Controls Contractor's (CC) Responsibilities

1. All requirements of MC and EC shall apply as applicable to the CC, including requirements for Submittals, O&M manuals and data, and training data and materials.
2. The CC is a crucial member of the Cx Team and will be required to be available for most FPTs, as well as verify, demonstrate and train the Operators on the overall system operation and sequence of operation. The CM shall ensure that the CC is made fully aware of his/her role and importance to a successful Cx effort.
3. Attend Cx Milestone meetings and training events as outlined in the Cx Plan and also as specified in appropriate control systems specification Section.
4. Attend and participate in all Cx FPT's per the Plan and spec. sections. The CC shall be required to demonstrate all control and system sequences of operation to the CxA and other members of the Cx Team.
5. Provide and participate all training in accordance with Contract Documents.

D. Equipment Suppliers and Miscellaneous Specialty Contractors

1. Attend Meetings as outlined in the Cx Plan.
2. Participate in training sessions as outlined in the Cx Plan and other Contract documents.
3. Demonstrate performance of equipment as applicable.

3.7 CONTRACTOR NOTIFICATIONS

- A. Contractors shall completely install, thoroughly inspect, startup, test, adjust, and balance systems and equipment. All activities shall be documented on Start-Up Documentation forms developed by the Contractor and reviewed by the CxA. The Contractor shall notify Owner and CxA in writing that systems are complete and ready for verification and FPT. CxA shall then coordinate and schedule the FPT and notify all Cx Team members.

- B. Contractor shall notify CxA at least 14 days in advance of any tests, startups, or training. CxA shall witness selected tests and startups. Minimum requirements for Start-up Documentation are provided in Part 2 of this section.

3.8 START-UP AND PRE-FUNCTIONAL TESTING PROCEDURES

- A. Refer to Division 26 and other applicable specification sections for specific start-up procedures for HVAC equipment. Unless otherwise noted, these procedures are the direct responsibility of the Contractor as a basic element of validating that the installation is correct. The manufacturer start-up forms shall be completed and submitted to the CM and CxA for review in accordance with the Cx Plan.
- B. The CxA shall provide pre-functional checklists to the Contractor electronically. The Contractor is responsible for completing these forms and submitting the completed forms to the CM and CxA for review in accordance with the Cx Plan.
- C. Functional Performance Tests provide the final metric for CxA approval and are provided by the CxA in the Cx Plan. Contractor shall consult the most current version of the Cx Plan to determine applicable FPTs that will be used for system acceptance.

3.9 GENERIC FUNCTIONAL PERFORMANCE TESTS (FPT)

A. General

- 1. Contractor shall refer to the Cx Plan for detailed information concerning the scheduling, prerequisites, and generic system/equipment testing requirements for the functional performance tests.

END OF SECTION 260800

SECTION 260923 - STAND-ALONE LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Switches.
- B. Occupancy sensors.
- C. Lighting contactors.
- D. Time-based control devices.
- E. Photocells.

1.14 RELATED SECTIONS

- A. Section specifying requirements for LEED rating is specified in Division 01.
- B. Identification for electrical systems: Section 260553.
- C. Modular dimming controls: Section 260936.
- D. Interior lighting: Section 265100.
- E. Exterior lighting: Section 265600.
- F. Commissioning requirements: Divisions 01 and 23.

1.20 REFERENCES

- A. IECC: International Energy Conservation Code.
- B. NECA 1: Standard Practices for Good Workmanship in Electrical Construction.
- C. NFPA 70: National Electrical Code.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data: Each type of device used in the project.
- C. Bill of materials: Provide detailed list of components and quantities.
- D. Shop drawings: Detail assemblies of standard and project specific components. Indicate dimensions and arrangement of components.
 - 1. Floor plans: Identify locations of lighting control system components; interconnection of components. Utilize reflected ceiling plans to show location, orientation, and coverage area of sensors.
 - 2. Wiring diagrams: Power, signal, and control wiring, differentiating between manufacturer-installed and field-installed wiring, provided on a schematic diagram.

3. Include representative views of components, including button layouts, engraving, colors, and other physical characteristics pertinent to each device.

E. Field quality control test reports.

F. Qualifications of factory certified field service engineer.

G. Operation and maintenance data: For lighting control system and associated components, provide product data, shop drawings, and test reports in operation and maintenance manual. In addition to items specified in Division 01, include list of replacement parts and assemblies.

1.40 QUALITY ASSURANCE

A. Comply with requirements for LEED certification specified in Division 01.

B. Devices shall be UL listed and labeled for their intended application.

C. Provide services from factory certified field service engineer to perform functional testing.

D. Qualifications for factory certified field service engineer:

1. Minimum experience of 2 years training in the electrical/electronic field.
2. Certified by the equipment manufacturer on the system installed.

1.50 DELIVERY, STORAGE, AND HANDLING

A. Store components indoors in a clean dry space with uniform temperature to prevent condensation. Protect switches from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.85 COMMISSIONING

A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01 for Commissioning Requirements.

B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

PART 2 - PRODUCTS

2.20 SWITCHES

A. Manufacturers:

1. Pass & Seymour/Legrand (basis-of-design).
2. Leviton Manufacturing Co.
3. Hubbell/Bryant Electric.
4. Cooper Industries/Eaton Wiring Devices.

B. Provide devices conforming to UL 20, equal to the following P&S catalog numbers:

1. Switches: PS20AC1, PS20AC3 (3-way), PS20AC4 (4-way).

2. Switches, weatherproof: PS20AC1, PS20AC3 (3-way), PS20AC4 (4-way), with CA1-GL cover.

C. Device color: Brown.

D. Device plates: Equal to Pass & Seymour, Type 302 stainless steel, SS Series.

2.21 OCCUPANCY SENSORS

A. Acceptable manufacturers

1. Acuity Brands Lighting, Inc./Sensor Switch.
2. Eaton/Cooper Controls/Novitas.
3. Hubbell Inc.
4. Lutron Electronics Co., Inc.

B. Wall switch occupancy sensors: Wired, dual-technology sensor, combination ultrasonic/passive infrared detector with override switch, capable of installation in a standard wall switch backbox.

1. Line voltage: Rated at 120/277 dual-input voltage, 60 hertz.
2. Device finish: White, with matching device plate.

a. Device plate shall be decorator style with mounting screws above and below device.

C. Ceiling-mounted occupancy sensors: Wired, dual-technology, combination ultrasonic/passive infrared detector, independently adjustable for installed conditions.

1. Dual-technology detector: Includes both passive infrared and ultrasonic detectors:

- a. Passive infrared: Utilize multiple segmented lens with internal grooves to eliminate dust and residue build-up, with field adjustable ambient light adjustment.
- b. Ultrasonic: Utilize an operating frequency of 32 kHz or 40 kHz, controlled to operate within plus/minus 0.01 percent tolerance. Detector shall automatically adjust detection threshold to compensate for learned environmental behavior.

2. Characteristics:

- a. Indicator: LED positive detection.
- b. Adjustable delayed off-time range: Between 30 seconds and 15 minutes.
- c. Capable of installation in acoustical ceiling tile or gypsum ceiling. Detector shall have 360-degree coverage, minimum 900 square feet.
- d. Fail on: Lights will stay on if sensor fails.
- e. Isolated relay: Provide an internal auxiliary set of contacts with Normally Open, Normally Closed, and Common outputs to allow other systems to monitor occupancy. For use with HVAC control system, or other control options where indicated.

3. Auxiliary components:

- a. Power pack: Universal 120/277V switched input, controlled through a high-current 20A relay. Low voltage output, less than or equal to 24VDC, for powering low voltage occupancy sensors. Enclosure shall be plenum rated.

- b. Override switch: Low-voltage switch shall operate on voltage less than or equal to 24VDC and shall have a momentary contact actuator to send a signal to the associated power pack to change the current lighting state. Color shall match switch device color specified above.

D. Sensor finish color: White.

2.22 LIGHTING CONTACTORS

- A. Lighting contactors: Equal to Square D 8903, UL 508 listed, in NEMA 250 Type 1 enclosure, mechanically held, electrically operated, enclosed silver-alloy double-break contacts, coil-clearing contacts; withstand rating as indicated on the drawings; Hand/Off/Auto selector switch on cover.
 - 1. Provide contactor with two-wire control relay for two-wire control of mechanically held lighting contactor.

2.23 TIME-BASED CONTROL DEVICES

- A. Digital timeclock: Equal to TORK, EWZ Series, electronic 365-day microprocessor-based, solid-state, two-channel control, with 24-hour programming capability and feature to provide automatic tracking of sunrise and sunset times in order to automatically turn lights On at dusk and Off at dawn, selectable to channel.
 - 1. Provide one additional On and Off event per channel as well as selectable daylight savings time adjustment and automatic leap year correction.
 - 2. Include skip-a-day, Offset to sunrise and sunset, and manual override, independently programmable for each channel.
 - 3. Latitude: Adjustable from 10 to 60 degrees northern or southern hemisphere.
 - 4. Clock format: AM/PM.
 - 5. Unit shall be capable of operating during a power outage for 100 hours with a capacitor.
 - 6. Unit shall be DIN rail or surface-mounted in a NEMA 250 Type 1 enclosure.
- B. In-wall timer; Solid-state interval timer with manually operated toggle switch for installation in a 2.5-inch deep single-gang or multi-gang wall box, 120/277-volt input, 4-ampere rated contacts, flicker warning before timing out, complete with properly marked cover plate. Time cycle adjustable from 15 minutes to 12 hours and set at 6 hours.
 - 1. Single-pole type: Equal to TORK/NSi Industries, Model SS20F, with minimum 150-watt load at 277 volts.
 - 2. Three-way type: Equal to TORK/NSi Industries, Model SS13F, with minimum 70-watt load at 277 volts.

2.26 PHOTOCELLS

- A. Open-loop exterior photocell: Equal to TORK, 2100 Series, 120/277 volt.
 - 1. Cell: Cadmium sulphide, epoxy coated, 1-inch diameter.
 - 2. Operation: Turn ON below 3 foot-candles; turn OFF within 3 to 12 foot candles; 2-minute time delay to prevent false switching.
 - 3. Temperature rating: Minus 40 degrees F (minus 40 degrees C) to plus 140 degrees F (60 degrees C).
 - 4. Contacts: Single-pole, single-throw, normally closed and fail in the ON position.
 - 5. Housing: Die-cast aluminum or zinc with weather protection gasket.

6. Mounting: Fixed base with 0.5 inch (13-mm) threaded nipple.

2.30 CONDUCTORS AND CABLES

- A. Wiring to supply side of remote-control power sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519, Wires and Cables.
- B. Low-voltage control cable: Manufacturer's standard multi-conductor cable with stranded-copper conductors not smaller than No. 22 AWG, plenum rated.
 1. Class 2 Control Cables: Multi-conductor cable with copper conductors not smaller than No. 18 AWG.
 2. Class 1 Control Cables: Multi-conductor cable with copper conductors not smaller than No. 14 AWG.
- C. Digital UTP cabling: Unshielded, twisted-pair cable with copper conductors, complying with TIA/EIA-568-B.2, Category 5E for horizontal copper cable.

2.40 DEVICE PROGRAMMING REQUIREMENTS

- A. Programming of lighting controls shall be performed by a factory certified field service engineer. Refer to lighting controls diagrams on the Drawings.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Install devices in complete compliance with the manufacturer's recommendations.
- B. Provide a single cover plate where two or more devices are grouped together in one box.
- C. Verify door swings with door frame installed prior to rough-in for switches.
- D. Ground components according to Section 260526, Grounding and Bonding.
- E. Fully document control device calibration settings after system programming with manufacturer's representative and submit this information as a part of the O&M manual.
- F. Devices shall be installed and programmed to meet the control intent.
- G. Manufacturer's factory certified field service engineer shall provide start-up service, including physical inspection of lighting control system and connected wiring and final adjustments to meet specified performance requirements.

3.21 INSTALLING OCCUPANCY SENSORS

- A. Install in accordance with manufacturer's written instructions.
- B. Provide line voltage type detectors when a single wall device controls lighting within a single space.
- C. Provide low voltage type detectors when ceiling detector(s) controls a single space.

- D. Coverage pattern: Verify coverage pattern of single detector or system of detectors to be capable of complete coverage of the space in which the lighting is intended to be controlled. Provide additional detectors as necessary to satisfy complete coverage.
- E. Programming requirements:
 - 1. Vacancy mode (manual on, automatic off).
 - 2. Occupancy mode (automatic on, automatic off).

3.59 IDENTIFICATION

- A. Materials: Refer to Section 260553, "Identification for Electrical Systems." Identify devices and wiring.
- B. Lighting control stations:
 - 1. Custom engraving: Provide custom engraving on each button of each control station, defining button's function. Coordinate with owner for final approval of engraving.

3.60 FIELD QUALITY CONTROL

- A. Manufacturer's field service: Engage a factory certified field service engineer to test and inspect components, assemblies, and equipment installations, including connections.
- B. Functional testing. Perform tests and prepare test reports for the following:
 - 1. For occupancy sensors, confirm that the placement, sensitivity, and time-out settings are optimized to ensure lights turn off only after each space is vacated and do not turn on unless the space is occupied.

END OF SECTION 260923

SECTION 260936 - MODULAR DIMMING CONTROLS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Lighting relay room controllers (0-10V dimming relay network capable controllers).
- B. Lighting control stations (low-voltage digital wall stations).
- C. Sensor devices (occupancy sensors and daylight sensors).
- D. Auxiliary devices (interfaces and power supplies).
- E. Conductors and cables.
- F. Cost of system startup and testing shall be included in contract sum.

1.14 RELATED SECTIONS

- A. Section specifying requirements for LEED rating is specified in Division 01.
- B. Commissioning requirements: Division 01.
- C. Electrical identification: Section 260553.
- D. Stand-alone lighting control devices: 260923.
- E. Interior lighting: Section 265100.
- F. Mechanical system controls: Division 23.

1.20 REFERENCES

- A. IECC: International Energy Conservation Code.
- B. NECA 1: Standard Practices for Good Workmanship in Electrical Construction.
- C. NFPA 70: National Electrical Code.
- D. UL 924: Emergency Lighting and Power Equipment.

1.21 DEFINITIONS

- A. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.
- B. Zone: A fixture or group of fixtures controlled simultaneously by a single dimmer/relay.

1.26 DESIGN REQUIREMENTS

- A. Lighting controls shall meet the mandatory control requirements as defined in IECC 2015 energy code. Select control strategies implemented by the lighting systems may go beyond these requirements to support LEED certification.

1.27 PERFORMANCE REQUIREMENTS

- A. Provide a complete, digital, network capable, lighting control system. Lighting control system shall include equipment necessary for the proper operation and program of the lighting control system including 0-10V dimming relay controllers, control stations, sensors, and other interfaces, with communications interface provisions to a future network-based lighting controls system server.
- B. System shall be able to meet the functionality and sequence of operation(s) as listed on the Drawings.
- C. Each 0-10V dimming relay shall be individually controllable and shall include on-off, dimming, scene settings, and other control functions to meet designated sequence of operation(s).

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data: Manufacturer's technical product datasheet for each system component including assembly ratings and dimensioned plans, sections, and elevations showing minimum clearances, cable termination sizes, conductor entry, gutter space, and installed features, where applicable.
- C. Bill of materials: Detailed list of components and quantities.
- D. Shop drawings: Detail assemblies of standard and project specific components. Indicate dimensions and arrangement of components.
 - 1. Floor plans: Identify locations of lighting control system components; interconnection of components. Utilize reflected ceiling plans to show the following:
 - a. Location, orientation, and coverage area of sensors.
 - b. Locations of lighting relay room controllers and lighting control stations.
 - 2. Summary list of control devices, sensors, other loads, and interface devices.
 - 3. Wiring diagrams: Power, signal, and control wiring, differentiating between manufacturer-installed and field-installed wiring, indicated on a schematic diagram.
 - 4. Include representative views of components, including button layouts, engraving, colors, and other physical characteristics pertinent to each device.
 - 5. Load schedules: Indicate connected load, load type, and voltage per circuit, circuits and their respective control zones, circuits that are on emergency, and capacity, phase, and corresponding circuit numbers.
- E. Source quality-control test reports.
- F. Field quality-control test reports.
- G. Qualifications of factory certified field service engineer.
- H. Operation and maintenance data: For lighting control system and associated components, include product data, shop drawings, and test reports in operation and maintenance manual. In addition to items specified in Division 01, include the following:
 - 1. List of replacement parts and assemblies.

1.40 QUALITY ASSURANCE

- A. Comply with requirements for LEED certification specified in Division 01.
- B. System components shall be UL listed and labeled for their intended application.
- C. Qualifications for factory certified field service engineer to perform functional testing:
 - 1. Minimum experience of 2 years training in the electrical/electronic field.
 - 2. Certified by the equipment manufacturer on the system installed.
- D. Obtain lighting controls system components from a single source with total responsibility for compatibility of lighting control system components and lighting fixtures.
- E. Lighting control system installation shall comply with NFPA 70, as well as applicable ANSI and IEC standards, and FCC regulations.
- F. Lighting control system shall meet IEC801-2, tested to withstand a 15kV electrostatic discharge without damage or loss of memory.
- G. Technical support:
 - 1. Onsite support: Manufacturer's authorized service and maintenance representative characteristics shall include the following:
 - a. Located in the Baltimore/Washington, DC metropolitan area.
 - b. Staff is factory employed and trained.
 - c. Service available 24 hours a day, seven days a week, 365 days a year.
 - d. Maintains an adequate stock of manufacturer's genuine or approved parts to service this equipment.
 - e. Service and maintenance contracts available.
 - 2. Phone support: Toll free technical support shall be available.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Do not deliver or install equipment until spaces are enclosed and weather-tight, wet work in spaces is complete and dry, work above equipment 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.
- B. Store components indoors in a clean dry space with uniform temperature to prevent condensation. Protect switches from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.60 PROJECT CONDITIONS

- A. Environmental conditions: Lighting control system components shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - 1. Ambient temperature: 0 to 40 degrees C.
 - 2. Relative humidity: 5 to 90 percent, non-condensing.

1.80 WARRANTY

- A. Special warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lighting control system and associated auxiliary components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty period: Two years from date of substantial completion.
 - 2. Warranty shall include all parts and labor with no deductible.
 - 3. Warranty shall begin at the date the equipment is accepted by the Owner.
- B. Warranty service: Qualified personnel shall be available to repair or replace components of lighting control system and associated auxiliary components that fail in materials or workmanship. Furnish Owner with a telephone number where service representative can be reached at all times. Service personnel shall be at the site within 48 hours after receiving a request for service, and shall restore the lighting control system to proper operating condition within 72 hours.

1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01 for Commissioning Requirements.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

1.91 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged in protective box or covering for storage and identified with labels describing contents.
 - 1. Lighting relay room controllers: A minimum of two (2).
 - 2. Occupancy sensors: A minimum of ten (10).
 - 3. Daylight sensors: A minimum of five (5).
 - 4. Lighting control stations (low-voltage digital wall switches): Five (5) of each type.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide products manufactured by Lutron Electronics Co., Inc., Energi Savr Node series, or comparable product by one of the following:
 - 1. Acuity Brands Lighting, Inc., Blue Box series / MicroPanel series.
 - 2. Eaton/Cooper Controls, Greengate series.
 - 3. Lutron Electronics Co., Inc., Energi Savr Node series (basis-of-design).

2.09 SYSTEM REQUIREMENTS

- A. General system operation:

1. System shall be capable of receiving input signals from lighting control system sensors, lighting control stations (low-voltage digital wall switches), 0-10V control relays, and fire alarm control modules; and sending signals to lighting relay room controllers.
 2. Each input and controlled device shall be connected to associated lighting relay room controller via a low-voltage signal loop.
- B. System shall comply with UL standards including UL 916 and UL 924.
- C. System requirements:
1. Emergency mode: Lighting relay room controllers and associated lighting fixture LED drivers shall comply with UL 924 requirements and operate under the following conditions:
 - a. Loss of power: Upon loss of power to a lighting relay room controller, lighting relays shall operate in the closed ('on') position and associated LED drivers shall operate in a full light output state. Once normal or backup power is restored, lighting relays shall remain in the closed ('on') position and LED drivers shall remain in a full light output state until a new command is initiated.
 - b. The default settings for emergency-designated fixtures shall not be capable of being modified.
 - c. Fire alarm system input: Upon alarm signal from the fire alarm system, lighting relays shall operate in the closed ('on') position and associated LED drivers shall operate in a full light output state. Upon alarm silencing, lighting relays shall remain in the closed ('on') position and LED drivers shall remain in a full light output state until a new command is initiated.
 2. Occupancy detection: The system shall reduce the power consumption in vacant areas by reading the status of low voltage occupancy sensors.
 - a. Occupancy sensor wiring: Occupancy sensors shall be wired directly to the associated lighting control system room controller for power and communications. Where the number devices/sensors exceed the amount allowed for a room controller, provide necessary interface devices and power packs to meet controllability intent of the contract documents.
 - b. Occupancy sensor groupings: The set of light fixtures that are controlled by a given occupancy sensor shall be configurable through system software and shall not require any manual wiring to modify.
 - c. Occupancy sensor modes: Each occupancy sensor shall have the following programmable lighting modes:
 - 1) Occupied mode: The occupied mode represents the lighting mode when occupancy is detected. Light levels will remain at the occupied level until occupancy is no longer detected.
 - 2) Setback or transition mode: Transition or setback modes provide a gradual change in light levels when occupancy is no longer detected.
 - 3) Vacancy mode: The vacancy mode represents the lighting mode when occupancy is no longer being detected and setback and transition levels have expired.
 3. Daylight harvesting: The lighting system shall adjust light levels (100-percent light level to 10-percent light level) in response to varying ambient light levels in a continuous and imperceptible manner in order to maintain a constant light level at desk height. Ambient light levels shall be determined from daylight sensors.

- a. Daylight sensor wiring: Daylight sensors shall be wired directly to the associated lighting relay room controller for power and communications. Where the number devices/sensors exceed the amount allowed for a room controller, provide necessary interface devices and power packs to meet controllability intent of the contract documents.
 - b. Daylight sensor groupings: The set of zones that are controlled by a given daylight sensor shall be configurable through system software and shall not require manual wiring to modify.
 - c. Daylight sensor settings: Settings associated with a given daylight sensor shall be adjustable through system software and shall not require any physical adjustment to the sensor itself.
4. Future remote access: Operating parameters of the lighting control system shall have the capability to be configurable from any internet enabled computer through a web-browser and a network connection to a future lighting controls system server.

2.21 LIGHTING RELAY ROOM CONTROLLERS

- A. Product: Equal to Lutron, Model QSN-4T16-S (0-10V control), custom programmed, network capable.
- B. Characteristics:
 1. Enclosure: NEMA 250 Type 1, steel.
 2. Delivered and installed as a UL listed factory assembly.
 3. Input power: Dual-rated 120/277-volt, 60 hertz, phase to neutral.
 4. Feed-through type.
 5. Relays:
 - a. 20-ampere, 120/277-volt rated.
 - b. Independently addressable.
 - c. Minimum of 500,000 switching cycles at full load.
 6. Capable of switching the following load types:
 - a. Light emitting diode (LED) lighting fixtures/luminaires.
 - b. 20-ampere rated receptacle or plug loads.
- C. Functionality: Functions of associated lighting control stations shall be set up at the lighting relay room controllers' electronic controls that include indicated number and arrangement of scene presets, channels, and operational times.

2.22 LIGHTING CONTROL STATIONS (LOW-VOLTAGE DIGITAL WALL STATIONS)

- A. Description: Low-voltage, field-programmable digital wall station device with button configurations and functions as shown in the lighting controls diagrams on the Drawings.
- B. Functionality: Lighting control station(s) shall provide an immediate local LED illumination response upon button activation to indicate that a system command has been requested. LED will remain lit contingent upon receiving system confirmation of the successful completion of the command.

1. Each button shall be capable of performing an 'On' or 'Off' operation of the programmed zone.
 2. Buttons shall be capable of modifying the state of multiple zones to create a scene.
 3. Lighting control station(s) with raise/lower buttons shall have capability of raising or lowering light levels.
- C. Lighting control stations shall have control over programmed scenes.
- D. Lighting control stations shall be engraved with appropriate zone and scene descriptions, furnished to the manufacturer prior to fabrication. Size and style of engraving type shall be determined by the Architect during submittal stage. Any silk-screened borders, logos, graduations, etc. shall use a graphic process that chemically bonds the graphics to the faceplate, resisting removal by scratching, cleaning, etc. Coordinate exact engraving text with Owner prior to order. If Owner does not have a preference, use zone designations indicated on the Drawings.
- E. Lighting control station(s) functions shall be configurable from associated lighting relay room controller.
- F. Configurations: Button-based style with each button fully customizable to perform defined function. Button shall have toggle capability.
1. Provide multi-button configurations as detailed on the Drawings.
- G. Device finish: White, with matching device plate.
1. Device plate shall be decorator style with mounting screws above and below device.
- 2.23 SENSOR DEVICES
- A. Ceiling-mounted occupancy sensors: Wired, dual-technology, combination ultrasonic/passive infrared detector, independently adjustable for installed conditions.
1. Dual-technology detector: Includes both passive infrared and ultrasonic detectors:
 - a. Passive infrared: Utilize multiple segmented lens with internal grooves to eliminate dust and residue build-up, with field adjustable ambient light adjustment.
 - b. Ultrasonic: Utilize an operating frequency of 32 kHz or 40 kHz, controlled to operate within plus/minus 0.01 percent tolerance. Detector shall automatically adjust detection threshold to compensate for learned environmental behavior.
 2. Characteristics:
 - a. Indicator: LED positive detection.
 - b. Adjustable delayed off-time range: Between 30 seconds and 15 minutes.
 - c. Capable of installation in acoustic ceiling tile or gypsum ceiling. Detector shall have 360-degree coverage, minimum 900 square feet in rooms and minimum 2000 square feet in corridors.
 - d. Isolated relay: Provide an internal auxiliary set of contacts with Normally Open, Normally Closed, and Common outputs to allow other systems to monitor occupancy. For use with HVAC control system, or other control options where indicated.

- B. High-bay ceiling occupancy sensor: Wired, passive infrared detection capable of installation in high ceiling space and suitable for high-bay installations.
 - 1. Passive infrared detector: Utilize multiple segmented lens with internal grooves to eliminate dust and residue build-up, with field adjustable ambient light adjustment.
 - 2. Selectable delayed off-time settings.
 - 3. Detector shall have 360-degree coverage.
 - 4. Isolated relay: Provide an auxiliary set of contacts with Normally Open, Normally Closed, and Common outputs to allow other systems to monitor occupancy. For use with HVAC control system, or other control options where indicated.
- C. Daylight sensors: Wired, ceiling or fixture mounted open-loop interior photocell.
 - 1. Open-loop basis for daylight sensor control scheme. Continual monitoring of daylight entering building windows to enable daylight harvesting control of room lighting.
 - 2. Partially shielded for accurate detection of available daylight to prevent fixture lighting and horizontal light component from skewing sensor detection.
 - 3. Provide linear response from 0 to at least 500 footcandles.
 - 4. Performance requirements: The lighting control system manufacturer or authorized representative shall provide daylight sensor layout that provides adequate coverage for performance requirements of each space.
 - a. Provide design layout of daylight sensor devices.
 - b. The lighting control system manufacturer shall arrange an onsite pre-installation meeting and system startup meeting. The lighting control manufacturer shall provide direction regarding sensor location and relocation should conditions require a deviation from indicated design locations.
 - c. Provide at no additional cost any additional daylight sensors or hardware required to meet sequence of operations.
 - d. Lighting control system manufacturer shall program or offer guidance to program areas utilizing daylight sensors to ensure conformance with contract document requirements.
- D. Sensor finish color: White.
- E. Sensor power packs: Provide when quantity of sensors exceeds the maximum allowable per control circuit. Provide sensor power packs where required for power connection to sensors. Plenum-rated, Class 2 control wiring between sensors and control units.

2.26 AUXILIARY DEVICES

- A. Emergency lighting interface:
 - 1. UL 924 listed when used with lighting relay room controller.
 - 2. Senses one phase or all three phases of building power.
 - 3. Signal to lighting relay room controller on emergency lighting to turn lights controlled by room controller to full-light output circuit if power on any phase fails.
 - 4. Accepts a contact closure input from fire alarm system.
- B. Power supplies: Provide power supplies as indicated or as required to power system devices and accessories; junction box-mounted power supply.
- D. Electronic low-voltage interface: Operates electronic low-voltage lighting with a smooth continuous Square Law dimming curve.

- E. Time clock: Astronomic, 7-day programmable, cable of communicating directly with lighting relay room controller.

2.30 CONDUCTORS AND CABLES

- A. Wiring to supply side of remote-control power sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519, Wires and Cables.
- B. Low-voltage control cable: Manufacturer's standard multi-conductor cable with stranded-copper conductors not smaller than No. 22 AWG, plenum rated.
 - 1. Class 2 control cables: Multi-conductor cable with copper conductors not smaller than No. 18 AWG.
 - 2. Class 1 control cables: Multi-conductor cable with copper conductors not smaller than No. 14 AWG.
- C. Digital UTP cabling: Unshielded, twisted-pair cable with copper conductors, complying with TIA/EIA-568-B.2, Category 5E or Category 6 for horizontal copper cable.

2.40 DEVICE PROGRAMMING REQUIREMENTS

- A. Programming of lighting controls shall be performed by a factory certified field service engineer. Refer to lighting controls diagrams on the Drawings.

2.90 SOURCE QUALITY CONTROL

- A. Perform full-function testing on 100 percent of system components and panel assemblies at the factory.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Install devices in complete compliance with the manufacturer's recommendations.
- B. Ground components according to Section 260526, Grounding and Bonding.
- C. Fully document control device calibration settings after system programming with manufacturer's representative and submit this information as a part of the O&M manual.
- D. Devices shall be installed and programmed to meet the control intent.
- E. Manufacturer's factory certified field service engineer shall perform start-up service, including physical inspection of lighting control system and connected wiring and final adjustments to meet specified performance requirements.

3.21 INSTALLING LIGHTING RELAY ROOM CONTROLLERS

- A. Room controllers shall be surface mounted in accessible ceiling space above entry door.
- B. Provide identification of ceiling grid below room controllers to locate device.

3.22 INSTALLING LIGHTING CONTROL STATIONS (LOW-VOLTAGE DIGITAL WALL SWITCHES)

- A. Provide a single cover plate where two or more devices are grouped together in one box.
- B. Verify door swings with door frame installed prior to rough-in for switches.

3.23 INSTALLING SENSOR DEVICES

- A. Install in accordance with manufacturer's written instructions.
- B. Occupancy sensors:
 - 1. Provide low-voltage type detectors.
 - 2. Coverage pattern: Verify coverage pattern of single detector or system of detectors to be capable of complete coverage of the space in which the lighting is intended to be controlled. Provide additional detectors as necessary to satisfy complete coverage.
 - 3. Install at least three feet away from HVAC diffusers, or as indicated in manufacturer's written instructions.
 - 4. Programming requirements:
 - a. Vacancy mode (manual on, automatic off).
 - b. Occupancy mode (automatic on, automatic off).
- C. Daylight sensors: Location of interior daylight sensors shall be determined by manufacturer's certified field service engineer, based on optimization calculations for greatest energy savings.
- D. Accessory interface devices: Where additional devices are required and need power connection, provide the following:
 - 1. 277-volt circuit: Connect to room/space unswitched normal lighting circuit using 2 #12 + #12 ground in 3/4-inch conduit.
 - 2. 120-volt circuit: Connect to nearest unswitched receptacle circuit using 2 #12 + #12 ground in 3/4 inch conduit.

3.59 IDENTIFICATION

- A. Materials: Refer to Section 260553, "Identification for Electrical Systems." Identify devices, wiring, and ceiling grid below locations of lighting relay room controllers.
- B. Lighting control stations: Provide custom engraving on each button of each control station, defining button's function. Coordinate with Owner for final approval of engraving prior to ordering.

3.60 FIELD QUALITY CONTROL

- A. Manufacturer's field service: Engage a factory certified field service engineer to test and inspect components, assemblies, and equipment installations, including connections.
- B. Engage a factory certified field service engineer to make site visits indicated to ensure proper system installation and operation. Visit duration shall be suitable to accomplish required tasks.
- C. First visit (Pre-installation): Make first visit prior to installation of wiring for lighting control system.
 - 1. Review:
 - a. Low-voltage wiring requirements.
 - b. Separation of power and low-voltage/data wiring.

- c. Wire labeling.
 - d. Lighting relay room controller locations.
 - e. Lighting control station locations.
 - f. Load circuit wiring.
 - g. Connections to other equipment.
 - h. Installer responsibilities.
 - i. Power panel locations.
 - j. Additional manufacturer installation requirements.
2. Define scope of second visit (typical classroom review): Coordinate with factory certified field service engineer for the area to serve as a mockup of the lighting control system in a typical classroom. Define installation requirements to be completed by second visit.
- D. Second visit (Typical classroom review):
1. Provide mockup of the lighting control system in a typical classroom where directed by the Owner and Architect to demonstrate operability and set quality standards for materials and installation. Mockup installation shall be complete including room controller, control stations, devices, and wiring. Owner and Architect shall review mockup prior to installation of lighting control system in other classrooms.
 - a. Approval of mockup does not constitute approval of deviations from the contract documents contained in mockup unless Architect specifically approves such deviations in writing.
 - b. Subject to compliance with requirements, approved mockup may become part of the completed work if undisturbed at time of substantial completion.
 2. Wiring and hardware review: Wiring connections and electrical equipment included in the scope of the lighting control system shall be assessed.
 3. Field testing: Sensor connections and lighting control station connections shall be verified.
 4. Additional requirements: Coordinate with factory certified field service engineer for additional installation requirements for the completion of the lighting control system.
 5. Submit test report.
- E. Completion of installation and programming: Make visits upon completion of installation of the lighting control system. Perform the following tests and inspections:
1. Wiring and hardware review: Wiring connections and electrical equipment included in the scope of the lighting control system shall be assessed.
 2. Field testing:
 - a. Verify connection to sensors and lighting control stations.
 - b. Ensure that control hardware and software are calibrated, adjusted, programmed, and in proper working condition in accordance with the contract documents and manufacturer's installation instructions.
 - c. For occupancy sensors, confirm that the placement, sensitivity, and time-out settings are optimized to ensure lights turn off only after each space is vacated and do not turn on unless the space is occupied.
 - d. For daylight sensors, confirm daylight sensor location is optimized to achieve maximum energy savings while maintaining the desired set point and that the light levels in the space are reduced relative to the amount of usable daylight in the space.

3. Tuning: Coordinate with factory certified field service engineer an on-site meeting with the Owner and Engineer to make required adjustments to the lighting control system for conformance with the original design intent.
 4. Operational test: After installing room controllers, control stations, and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
 5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 6. Submit test report.
- F. On-site training: Make two visits for on-site training as described under Article 3.81, Operating Instructions.
- G. Lighting control components shall be considered defective if they do not pass tests and inspections.
- H. Prepare test reports, including a certified report that identifies lighting control panels and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.80 SYSTEM STARTUP

- A. Upon completion of project, engage a manufacturer's certified field service engineer to perform startup service.
1. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
 2. Complete installation and startup checks according to manufacturer's written instructions.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 260500, "Common Work Results for Electrical", provide operating instructions.
- B. Engage a factory certified field service engineer to train Owner's maintenance personnel to adjust, operate, and maintain lighting control equipment and devices.
- C. On-site training:
1. Schedule at least two sessions of eight consecutive training hours of instruction time.
 2. Train Owner's facility management and maintenance personnel, and selected Owner representatives.
 3. Training shall include, but not be limited to, overview, adjustment, operation, use, maintenance, and demonstration of the lighting control system.
 4. The first training session shall occur within one month of substantial completion. The second training session shall be scheduled between 6 months and 9 months of substantial completion.
 5. Each training session shall include on-site demonstration of lighting control system functionality with the Owner.

END OF SECTION 260936

SECTION 262200 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Transformers for electric power 600 V and below.
- B. General-purpose transformer.
- C. K-rated transformer.

1.14 RELATED SECTIONS

- A. Equipment foundations: Section 260528.

1.20 REFERENCES

- A. NEMA ST 20: Dry-Type Transformers for General Applications.
- B. DOE 2016: Department of Energy federal law 10 CFR Part 431 "Energy Efficiency Program for Certain Commercial and Industrial Equipment."

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data: Each transformer, includes the following:
 - 1. Outline dimensions and weights.
 - 2. kVA rating.
 - 3. Primary and secondary voltage.
 - 4. Taps.
 - 5. Impedance.
 - 6. Insulation class and temperature rise.
 - 7. Sound level.
- C. Certifications:
 - 1. Specified sound levels.
 - 2. Compliance with DOE 2016 for energy efficiency.
- D. Test reports: Factory and field test reports specified in Parts 2 and 3 below.
- E. Unit shown on drawings is based on the characteristics of the design basis unit specified in Part 2. If another acceptable manufacturer's unit should be proposed, ascertain that it will meet the required standards and performance. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, showing any changes in wiring, arrangement or access made necessary to accommodate the unit proposed.
- F. Operation and Maintenance Data: For transformer to include in operation and maintenance manuals: In addition to items specified in Division 01 and Section 260101, include the following:
 - 1. Final settings for transformer taps and measured voltage.

1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 260500, Common Work Results for Electrical.
- B. UL Energy Verification Mark to confirm compliance with DOE 2016.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Square D Company (Schneider Electric) units are the basis for design of the project. The following listed manufacturers also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article "Product Options" in Section 260101, and submit shop drawings as specified in the article "Submittals" above.
 - 1. Eaton Corp; Cutler-Hammer Products
 - 2. General Electric Company
 - 3. Square D Company (Schneider Electric)

2.30 TRANSFORMERS, GENERAL

- A. Factory-assembled and -tested, air-cooled units of types specified, of size, phase, and voltage ratings indicated on the drawings, designed for 60-Hz service.
- B. Cores: Grain-oriented, non-aging silicon steel.
- C. Coils: Continuous copper windings without splices except for taps.
- D. Enclosure: Heavy-gage steel enclosure and base, arranged for conduit entrance on the primary and secondary sides and provided with adequate louvered openings to allow suitable ventilation and cooling. NEMA 250 Type 1.
- E. Enclosure Finish: Degreased, cleaned, phosphatized, primed and finished with baked enamel paint. Comply with NEMA 250; color manufacturer's standard gray.
- F. Taps: Four, 2.5 percent rated kVA taps, two below and two above rated primary voltages, except transformers rated 15 kVA and smaller may have two 5-percent-rated kVA taps, one above and one below rated primary voltage.
- G. Sound levels based on NEMA ST 20 test procedure:
 - 1. Transformer 50 kVA and smaller: Not more than 45 dB.
 - 2. Transformers 51 to 150 kVA: Not more than 50 dB.
 - 3. Transformers 151 to 300 kVA: Not more than 55 dB.
 - 4. Transformers 500 kVA: Not more than 60 dB.

2.31 GENERAL-PURPOSE TRANSFORMERS

- A. Self-cooled, dry type of size, phase, and voltage rating indicated on the drawings, designed in accordance with NEMA ST-20. Dry-type, general-purpose transformers shall be Energy Efficient type in compliance with DOE 2016.

- B. Insulation: The maximum hot spot temperature can be 30 degrees C higher than the specified average below.
 - 1. Transformers below 15 kVA: Class 150 degrees C having a maximum temperature rise under full load conditions not exceeding 115 degrees C when the transformer is operating in 40 degrees C ambient temperature.
 - 2. Transformers 15 kVA and higher: Class 220 degrees C having a maximum temperature rise under full load conditions not exceeding 115 degrees C when the transformer is operating in 40 degrees C ambient temperature.

2.40 K-RATED TRANSFORMERS

- A. Transformers evaluated by the UL K-Factor evaluation, UL listed and labeled for K-13, defined as the sum of fundamental and harmonic $1_h(\text{pu})^2h^2$ in accordance with UL 1561.
- B. Temperature:
 - 1. Neither the primary nor secondary temperature shall exceed 220 degrees C at any point in the coils while they carry their full rating of non-sinusoidal load (i.e., insulation shall be UL-recognized 220 degrees C system).
 - 2. Transformers shall be listed for no more than 115 degrees C average temperature rise.
- C. Transformers shall not have excessive neutral current when supplying loads with large amounts of third harmonic. Neutral bus shall be configured to carry 200 percent of rated current.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Mount on wall, ceiling, or floor as shown on the drawings. Transformers shall be level and plumb. Transformers shall not be mounted in corrosive areas.
 - 1. Wall mount: Use manufacturer's wall-mounted bracket in accordance with manufacturers' instructions.
 - 2. Ceiling mount: Use one of the following two methods:
 - a. Use manufacturer's ceiling-mounted bracket in accordance with manufacturers' instructions.
 - b. Field-fabricated trapeze mount: Trapeze mounting made from galvanized-steel strut or channel. Suspend trapeze from galvanized-steel rods, anchor to ceiling or structure above. If trapeze is adjacent to wall, additionally fasten to wall. Provide vibration isolation between transformer and trapeze or between trapeze and its supports.
- B. Floor mount: On equipment foundation (housekeeping pad).
- C. Mount exterior equipment on equipment foundation as shown on drawings.
- D. Ground neutrals of dry type transformers as specified in Section 260526, Grounding and Bonding and as required by NEC (NFPA 70).

3.22 INSTALLING TRANSFORMER

- A. Protect against overload on the primary side by circuit breakers in the panelboards as indicated.

- B. Install transformers on Isomode vibration isolator pads.
- C. Make immediate connections to and from transformers through flexible metal conduit.

3.59 IDENTIFICATION

- A. Materials: Refer to Division 26 Section "Identification for Electrical Systems."
- B. Nameplates: Refer to Division 26 Section "Identification for Electrical Systems" for additional requirements. Provide identification nameplate for each transformer located on front of assembly.

3.60 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's field service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- C. Remove and replace units that do not pass tests or inspections and retest as specified above.
- D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.70 ADJUSTING AND CLEANING

- A. Refinish painted surfaces damaged during construction to match the rest of the equipment.
- B. Measure voltage on the secondary side of transformer during a typical occupancy period and adjust taps to achieve nominal voltage output. Nominal voltage shall be plus three percent or minus two percent of nameplate secondary voltage.
- C. Record final tap settings and measured voltage and include in Operation and Maintenance manuals.

3.85 PROTECTION

- A. Apply temporary heat within indoor transformer enclosures, in accordance with manufacturer's recommendations, until the space temperature and humidity are under normal control.

END OF SECTION 262200

SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Service and distribution switchboards rated 600 V and less, for interior installation, including:
 - 1. Utility metering section
 - 2. Main switch section, circuit breaker type.
 - 3. Ground fault protection system.
 - 4. Distribution sections, circuit breaker type.
 - 5. Surge protective devices.

1.14 RELATED SECTIONS

- A. Fuses: Section 262813.
- B. Equipment foundations: Section 260528.
- C. Surge protective devices: Section 264313.

1.20 REFERENCES

- A. NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
- B. NEMA AB 1, Molded Case Circuit Breakers and Molded Case Switches.
- C. NEMA PB 2, Deadfront Distribution Switchboards.
- D. NEMA PB 2.1, Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 V or Less.
- E. UL 891, Dead-Front Switchboards.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data: For each type of switchboard including overcurrent protective devices, ground-fault protective devices, transient voltage suppression, and accessories. Include weights, dimensions, minimum clearances; and manufacturer's technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
- C. Shop drawings: For each switchboard, include the following:
 - 1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show method of field assembly, location, and size of each field connection.
 - 2. Single-line diagram representation of switchboard, bus configuration, current, and voltage ratings.
 - 3. Short-circuit current rating of switchboard assembly and overcurrent protective devices.
 - 4. Utility company metering provisions with indication of approval by utility company.

5. Scheduled of features, characteristics, ratings, and factory settings of individual protection devices.
 6. Wiring diagrams for power and control, differentiating between manufacturer-installed and field-installed wiring.
 7. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards.
- D. For service entrance switchboards, submit to utility company, BGE for approval.
- E. Coordination Drawings: Floor plans, drawn to 1/4"=1'-0" scale, on which the following items are shown and coordinated with each other based on input from installers of the items involved:
1. Dimensioned concrete base; outline of equipment; and required clearances; relationship between components and adjacent architectural, structural, and mechanical elements.
 2. Underground conduit stub-up locations, where applicable.
 3. Overhead conduit riser locations.
 4. Grounding cable locations and terminations.
 5. Identify equipment sections including front and rear orientation.
- F. Field quality-control test reports:
1. Results of field testing.
 2. Independent third-party testing of ground fault circuit interruption for service main overcurrent protection devices.
- G. Operation and maintenance data: For switchboards to include in the maintenance manuals specified in Division 01. Include manufacturer's detailed written instructions on adjusting overcurrent protective devices.
- 1.40 QUALITY ASSURANCE
- A. Source limitations: Obtain switchboards, overcurrent protective devices, components, and accessories 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 accepted by the authority having jurisdiction, and marked for intended location and application; listed as a complete assembly.
1. UL label and local testing (where required): As specified in 260500, Common Work Results for Electrical.
- C. Product selection for restricted space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- 1.49 COORDINATION
- A. Coordinate layout and installation of switchgear and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.
- B. Coordinate size and location of concrete bases.
- C. Coordination location of underslab conduit.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Delivery in sections of lengths that can be moved past obstructions in delivery path.
- B. Store equipment indoors in clean dry space with uniform temperature to prevent condensation. Protect equipment from exposure to dirt, fumes, water, corrosive substances, and physical damage.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Switchboards manufactured by Square D Company (Schneider Electric) are the basis for design of the project. The following listed manufacturers also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article "Product Options" in Section 260101, and submit shop drawings as specified in the article "Submittals" above.
 - 1. Eaton Corp; Cutler Hammer Products
 - 2. General Electric Company
 - 3. Square D Company (Schneider Electric)

2.31 MAIN SWITCHBOARD

- A. Service entrance and or distribution switchboard, NEMA PB 2, UL listed, in a NEMA 250 Type 1 enclosure except as indicated otherwise.
- B. Construction: Deadfront with front access.
 - 1. Formed code-gage steel, welded and bolted together to support cover plates, bussing, and component devices during shipment and installation.
 - 2. Finish: Gray enamel over a rust-inhibiting phosphate primer.
 - 3. Furnish each unit with a master nameplate, listing standard manufacturer information including voltage, ampacity, frequency, and short-circuit ratings; manufacturer's model and project designations.
- C. Sections: Each shall have an open bottom and individual removable top plate for installation and termination of conduit.
 - 1. Wireway front covers: Hinged to permit access to the branch breaker load side terminals without removing the covers.
- D. Bussing: Hard-drawn copper of 98 percent conductivity, silver plated and of sufficient cross-sectional area to meet UL 891 for temperature rise. Circuit breaker line connections shall be aluminum (tin-plated by "Alstan" 70 or 80 process) or copper.
 - 1. Through bus: Ampacity, and braced to have a short-circuit current rating of RMS symmetrical amperes, as shown on the drawings. The through bus shall have provisions for the addition of future sections. Bolt supports, connections and joints with grade 5 hex head bolts and belleville washers.

- E. Utility metering compartment: Fabricated compartment and section meeting utility company's requirements. If separate vertical section is required for utility metering, match and align with basic switchboard.

- F. Owner's metering:
 - 1. Meters: Multifunction digital meter mounted in a door, minimum 25 percent accuracy, and supplied with potential and current transformers. Meters shall have the ability to be read remotely over a RS-485 communications port.
 - a. Phase- (and neutral, where applicable) selectable meter functions shall include instantaneous current, instantaneous voltage, instantaneous real power, instantaneous reactive power, instantaneous complex power, power factor, and total harmonic distortion. Readings shall be true root-mean-square where applicable.
 - b. Meter shall also record peak demand per phase for real, reactive, and complex power, with date/time stamping.
 - c. Meter shall also record kilowatt-hours, kilovar-hours, and kilovoltamp-hours consumed.
 - d. Meter shall have a data log and an event log with a minimum memory of 100 kilobytes. Meter shall capture waveforms when triggered by disturbances (as defined in programming) in voltage or current.

 - 2. Potential and Current Transformers: ANSI C57.13.

- G. Main circuit breaker section: Enclosed, molded-case type circuit breaker, totally front-accessible and front-connectable. Line side circuit-breaker connections shall be jaw type plug-on.
 - 1. Circuit breaker: NEMA AB 1, handle lockable; frame size, trip rating, number of poles, and auxiliary devices as indicated; interrupting capacity rating to meet available fault current.
 - a. 200 A and larger: Trip units interchangeable within frame size.
 - b. 400 A and larger: Field-adjustable short-time and continuous current settings.
 - c. Lugs: Mechanical lugs and power-distribution connectors for number, size, and material of conductors indicated.

- H. Ground fault protection system for main section:
 - 1. Current sensor and relaying equipment: Split-core type current sensor shall enclose all phase conductors, and neutral conductors, if present, of the circuit to be monitored.
 - 2. Monitor panel: Include a push-to-test button for the test circuit and a red, ground fault indicator light which indicates the circuit interrupter has opened due to a ground fault condition.
 - 3. Test winding: Shall simulate the flow of ground fault current through the current sensor, in order to test the complete system, including sensor pickup, relaying equipment, and electric trip mechanism of the switch.
 - a. Ground fault relay: Solid-state construction, with adjustable pickup for ground fault currents from 200 amperes to 1200 amperes. Settings for individual relays shall be as shown on the drawings. Time delay provided by the field-adjustable ground fault relay circuitry shall have continuous settings from 0.03 to 0.6 seconds.

- I. Circuit breakers:
 - 1. Circuit breakers shall be suitable for mounting in the switchboard sections for which they are scheduled: Either group- or individually-mounted distributed sections.

- a. Group-mounted circuit breakers through 1200 A:
 - (1) Circuit breaker(s) shall be grouped-mounted plug-on with mechanical restraint on a common pan or rail assembly.
 - (2) The interior shall have three flat bus bars stacked and aligned vertically with glass reinforced polyester insulators laminated between phases. The molded polyester insulators shall support and provide phase isolation to the entire length of bus.
 - (3) Circuit breaker(s) equipped with line terminal jaws shall not require additional external mounting hardware. Circuit breaker(s) shall be held in mounted position by a self-contained bracket secured to the mounting pan by fasteners. Circuit breaker(s) of different frame sizes shall be capable of being mounted across from each other.
 - (4) Line-side circuit breaker connections shall be jaw type.
 - (5) Unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including appropriate connectors and mounting hardware.
2. Electronic trip molded case circuit breakers:
 - a. Circuit breakers shall be rated for 80 percent or 100 percent of nominal current, as indicated on drawings.
 - b. Circuit breakers shall have the following time/current response adjustments: Long time pickup, long time delay, short time pickup, short time delay, ground fault pickup, ground fault delay and instantaneous settings. Each adjustment shall have discrete settings (fully adjustable) and shall be independent of other adjustments.
 - c. Circuit breaker trip system shall be a microprocessor-based true root-mean-square sensing designed with sensing accuracy through the thirteenth harmonic. Sensor ampere ratings shall be as indicated on the associated schedule.
 - d. Provide local visual trip indication for overload, short circuit and ground fault trip occurrences.
 - e. Provide long time pickup indication to signal when loading approaches or exceeds the adjustable ampere rating of the circuit breaker.
3. Thermal magnetic molded case circuit breakers: Molded case circuit breaker(s), with integral thermal and instantaneous magnetic trip in each pole. Ampere and fault current-interrupting ratings shall be as noted on the drawings.

2.71 SURGE PROTECTIVE DEVICES (SPD)

- A. As part of the switchboard, provide service entrance SPD specified in Section 264313, Surge Protective Devices.

2.92 FACTORY TESTS

- A. Each switchboard, as a complete unit, shall be given a single short-circuit current rating by the manufacturer. Rating shall be established by actual tests by the manufacturer, in accordance with UL specifications, and on equipment similar to the switchboard provided for this project.

PART 3 - EXECUTION

3.02 EXAMINATION

- A. Examine elements and surfaces where switchboard will be installed for compliance with installation tolerances, required clearances, and other conditions affecting performance.

- B. Verify that equipment foundations are level and ready to receive equipment.
- C. Verify field measurements are as indicated on architectural drawings and coordination drawings.
- D. Verify that required utilities are available, in proper location, and ready for use.
- E. Beginning of installation indicates installer accepts conditions.

3.21 INSTALLATION

- A. Provide equipment foundation (housekeeping pad).
- B. Level switchboard in place before mounting and bolt to the foundation. Assemble sections as required by the manufacturer and in accordance with NEMA PB 2.1.
- C. Frame and mount printed operating instructions, including control and key interlocking sequences and emergency procedures, on front of switchboards.

3.25 CONNECTIONS

- A. Connect switchboards and components to wiring systems according to other sections of Division 26 and instructed by manufacturer's recommendations.
- B. Ground equipment according to Section 260526, Grounding and Bonding, and as instructed by manufacturer's recommendations.
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's values are not indicated, use those specified in UL 486A and UL 486B.

3.59 IDENTIFICATION

- A. Identify field-installed wiring and components as specified in 260553, Identification for Electrical Systems.
- B. Nameplates: Provide identification nameplate for each switchboard and each section, including associated components, located on front of assembly.

3.60 FIELD QUALITY CONTROL

- A. Inspect, test, and adjust the equipment. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
 - 1. Testing insulation resistance for each switchboard bus, components, and connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
 - 3. Test ground-fault protection of service entrance equipment.
- B. Operate equipment and check controls, including high- and low-limit controls.
- C. Ensure that the equipment functions properly by actual operation prior to final acceptance.
- D. Provide independent third-party testing of ground fault circuit interruption for service main overcurrent protection devices.

3.70 ADJUSTING

- A. Set field-adjustable, circuit breaker trip characteristics according to results in Section 260573, Overcurrent Protective Device Studies.

3.75 CLEANING

- A. Clean interior and exterior of switchboards.
- B. Refinish painted surfaces damaged during construction to match the rest of the switchboard.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 260500, Common Work Results for Electrical, provide operating instructions.

END OF SECTION 262413

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Circuit breaker panelboards, distribution and lighting and appliance branch-circuit types.
- B. Fusible distribution panelboards.

1.14 RELATED SECTIONS

- A. Identification for Electrical Systems: Section 260553.
- B. Overcurrent Protective Device Studies: Section 260573.
- C. Fuses: Section 262813.
- D. Surge Protective Devices: Section 264313.

1.20 REFERENCES

- A. ANSI/NECA 407: Recommended Practice for Installing and Maintaining Panelboards.
- B. NEMA 250: Enclosures for Electrical Equipment (1000 Volts Maximum).
- C. NEMA PB 1: Panelboards.
- D. NEMA PB 1.1: Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less.
- E. NETA ATS: Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
- F. UL 50: Enclosures for Electrical Equipment.
- G. UL 67: Panelboards.
- H. UL 1449: Surge Protective Devices.

1.21 DEFINITIONS

- A. Circuit-Breaker Panelboards in this section:
 - 1. Distribution panelboard: Capable of accepting up to 1200-A branch breakers.
 - 2. Lighting and appliance panelboard: Maximum branch breaker amperage 125 A.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data: For each type of panelboard, overcurrent protective device, surge protective device, accessory, and component indicated.

- C. Bill of Materials: Provide detailed list of components.
- D. Shop Drawings: For each type of panelboard, include the following details:
 - 1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings in panel schedule format.
 - 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. Features, characteristics, ratings, and factory settings of individual protective devices and auxiliary components.
- E. Operation and Maintenance Data: For panelboards and components to include in operation and maintenance manuals. In addition to items specified in Division 01 and Section 260101, include the following:
 - 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - 2. Time-current curves, including selectable ranges for each type of overcurrent protective device.
 - 3. Copy of each printed panelboard schedule representing final version following installation.

1.40 QUALITY ASSURANCE

- A. Do not submit equipment submittals prior to completing Short-Circuit and Coordination Study as indicated in Section 260573.
- B. Source limitations: Obtain panelboards, overcurrent protective devices, components, and accessories through one source from a single manufacturer.
- C. 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; listed as a complete assembly.
 - 1. UL label and local testing (where required): As specified in Section 260500, Common Work Results for Electrical.
- D. Comply with referenced standards and listings previously identified including NEMA PB 1, NFPA 70, and UL 67.

1.49 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.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Store equipment indoors in clean dry space with uniform temperature to prevent condensation. Protect equipment from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.60 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.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).

1.92 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. Keys: Two spares for each type of panelboard cabinet lock.
 2. Furnish spare breakers for panelboards as indicated in schedule on drawings.
 3. Furnish spare fuses for fused switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide scheduled Square D Company (Schneider Electric) panelboards or comparable product by one of the following:
1. Eaton Corp.; Cutler-Hammer Products
 2. General Electric Company
 3. Square D Company (Schneider Electric)

2.30 PANELBOARDS, GENERAL

- A. UL listing: UL 67, listed and labeled.
- B. Panelboards for service entrance shall be listed and labeled for service entrance.
- C. Integrated equipment short-circuit rating: Each panelboard, as a complete unit, shall have a short-circuit rating equal to or greater than the integrated equipment rating shown or scheduled on the drawings.
1. Rating shall be established by testing in accordance with UL 67, with the overcurrent devices mounted in the panelboard. Make short-circuit tests on the overcurrent devices and on the panelboard structure simultaneously, by connecting the fault to each overcurrent device with the panelboard connected to its rated voltage source. The source shall be capable of supplying specified panelboard short-circuit current or greater.
 2. Testing of overcurrent devices only while individually mounted is not acceptable. Testing the bus structure by applying a fixed fault to the bus structure alone is not acceptable.
 3. Mark each panelboard with its maximum short-circuit current rating at the supply voltage.

4. Series rating of panelboards with devices outside of the panelboard enclosure are not permitted.
- D. Enclosures: Flush- or surface-mounted as indicated, NEMA PB 1, Type 1, UL 50, galvanized steel.
1. Size: Where multiple-width or multiple-section panelboards are indicated or required, each cabinet shall be the same width and height.
 2. Provide enclosure type as indicated below or listed on drawings:
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Outdoor Locations: NEMA 250, Type 3R.
 - c. Kitchen Areas: NEMA 250, Type 4X.
- E. Directory card: Inside panelboard door, mounted in metal frame with transparent protective cover with information as indicated in Part 3, Identification.
- F. Provisions for future devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- G. Furnish each unit with a master nameplate, listing standard manufacturer information including voltage, ampacity, frequency, and short-circuit ratings; manufacturer's model and project designations.

2.31 CIRCUIT-BREAKER PANELBOARDS

- A. Factory-assembled complete with breakers.
- B. Cabinets and fronts: Minimum 20 inches wide, wiring gutter space in accordance with UL 67, with minimum four-inch width on every side.
1. Cabinet front: Hinged trim with entire front hinged to cabinet box with piano hinge and screw fasteners for surface mounted cabinets.
 2. Door: Required for sizes up to and including 600 amps.
 - a. Lock: Flush, cylinder tumbler type, with catch and spring-loaded stainless steel door pull. All panelboards shall be keyed alike. Provide two keys per lock. Provide extra keys as required in "Extra Materials" in Part 1 above.
 - b. Hinges: Steel, completely concealed.
- C. Circuit breakers: UL 489; voltage, continuous-current rating, and interrupting rating as indicated on the drawings or determined by the results of the Short-Circuit Analysis performed under Section 260573, whichever is greater.
1. Breakers shall be 1-, 2- or 3-pole, with an integral crossbar to ensure simultaneous opening of all poles in multipole circuit breakers.
 2. Operating mechanism: Over center, trip-free, toggle-type with quick-make, quick-break action. Handles shall have on, off, and tripped positions.
 3. Circuit breakers shall be able to be installed in the panelboard without requiring additional mounting hardware or disturbing adjacent units, bars, or branch circuit connections.
 4. Where indicated on the drawings, provide shunt-trip main breakers, standard main breakers, or lugs.

5. Main and branch circuit breakers shall have device ampacity rating engraved on the front or side of each breaker handle. The breaker rating shall be clearly visible without removing panelboard cover.
 6. Circuit breakers shall be rated for use with 75 deg C wire (conductor temperature rating).
 7. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 amps and larger.
 8. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front mounted, field-adjustable trip setting.
 9. Ground-Fault Circuit Interrupter (GFCI) type circuit breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 10. Tandem breakers are not permitted.
- D. Bussing assembly and temperature rise: Panelboard bus structure and main lugs or main circuit breaker shall have current ratings as shown on the panelboard schedule, established by heat rise tests conducted in accordance with UL 67.
1. Conductor dimensions shall not be accepted in lieu of actual heat tests.
 2. Current-carrying parts of the bus structure shall be hard-drawn copper, 98 percent conductivity.
 3. Provide a separate copper ground bus with screw terminals for branch wiring and feed-through lugs.
 4. Where indicated on the drawings, provide a neutral bus sized for 200 percent of the panelboard bus rating. Panels with 200 percent neutrals shall be designed for use with nonlinear loads.
- E. Additional Connections: Where indicated on drawings, provide the following:
1. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 2. Sub-feed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
- F. Distribution panelboards: Distribution panelboard shall be capable of accepting up to 800 ampere branch breakers, or as indicated on drawing panel schedules. Current characteristics shall be as scheduled on the drawings.
- G. Branch circuit panelboards: Panelboard shall be capable of accepting up to 100-amp branch breakers.
1. Single-pole, 15 and 20 A circuit breakers intended to switch fluorescent lighting loads on a regular basis shall carry the SWD marking.
 2. Branch breakers serving exit lights, fire alarm, shall be provided with handle-blocking devices which shall prevent accidental operation but not prevent tripping.
- 2.32 FUSIBLE DISTRIBUTION PANELBOARDS
- A. Fusible distribution panelboards shall be as indicated in the panelboard schedule and provided where shown on the drawings.
- B. Type: Deadfront, equipped with quick-make, quick-break fusible branch switches.

- C. Bus structure and main lugs or main switch: Current ratings as shown on the panelboard schedule. The bus structure shall accommodate plug-on or bolted branch switches, as indicated in the panelboard schedule, without modification to the bus assembly.
- D. Fusible branch switches: Quick-make, quick-break, with visible blades and dual horsepower ratings.
 - 1. Switch handles shall physically indicate On and Off positions.
 - 2. Switches shall be lockable only in the Off position and shall accept three industrial-type heavy-duty padlocks.
 - 3. Switch covers and handles shall be interlocked to prevent opening in the On position. Provide a means to permit authorized personnel to release the interlock for inspection purposes.
 - 4. Provide a circuit identification cardholder for each branch switch.
- E. Panelboards shall be UL listed for use on a system capable of delivering not more than 200,000 rms symmetrical A at 600 V ac maximum when all branch switches are equipped with rated Class J fuses.

2.40 SURGE PROTECTIVE DEVICE (SPD)

- A. As part of the panelboard, provide service entrance SPD specified in Section 26 4313, Surge Protective Devices where indicated on drawings. Note the requirement of that section for a single manufacturer to provide all SPD of all types in the project.

2.90 SOURCE QUALITY CONTROL

- A. With branch circuit breakers installed, short-circuit test panelboards as complete units, in accordance with requirements of UL 67.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Securely attach panelboards to the wall where indicated on the drawings. Install in accordance with NEMA PB 1.1 and manufacturer's written installation instructions.
 - 1. Mounting height:
 - a. 72 inches (1829 mm) to top of panelboard.
 - b. Panelboards taller than 72 inches (1829mm): Bottom edge no more than 4-inches (102 mm) above floor.
 - c. Top breaker maximum height: No more than 6-feet, 7-inches (2.0 m) above the floor or working platform.
- B. Comply with applicable portions of NECA 407.
- C. Frame and mount printed circuit directory indicating type and location of equipment on each circuit.
- D. Wiring in gutters: Arrange conductors into groups, and bundle and wrap with wire ties.
- E. Install filler plates in unused spaces.

3.25 CONNECTIONS

- A. Connect panelboards and components to wiring and to ground as indicated.
- B. Shared neutral conductors shall not be permitted, except where indicated.
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's values are not indicated, use those specified in UL 486A and UL 486B.

3.59 IDENTIFICATION

- A. Materials: Refer to Division 26 Section "Identification for Electrical Systems." Identify units, auxiliary devices, controls, and wiring. Identify equipment ratings.
- B. Nameplates: Refer to Division 26 Section "Identification for Electrical Systems" for additional requirements. Provide identification nameplate for each panelboard and associated components located on front of assembly.
- C. Identify field-installed wiring and components. Refer to Division 26 Section "Identification for Electrical Systems" for additional requirements.
- D. Provide printed directory for each panelboard. Handwritten directories are not acceptable. Copying of panel schedules and descriptions on drawings is not acceptable. Circuit directory shall reflect final circuit installation. Include the following information:
 - 1. Panelboard designation and room location.
 - 2. Circuit breakers, size and number of poles.
 - 3. Circuit or feeder description including destination room name(s) and number(s).
 - 4. Clear description of type of load circuit serves.
 - 5. Panelboard ratings: Main bus ampacity, main circuit breaker or main lug ampacity, AIC rating.
 - 6. Incoming primary feeder size and source panelboard circuit designation.
- E. Room names and numbers on the panelboard circuit directories shall match names and numbers used by the Owner. Note that room names and numbers on the drawings may not match the Owner's final room name and numbering scheme.

3.60 FIELD QUALITY CONTROL

- A. Make insulation-resistance tests of each panelboard bus, component, and connecting supply, feeder, and control circuit.
- B. Make continuity tests of each circuit.
- C. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- D. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.75 CLEANING

- A. Clean interior and exterior of panelboards.

- B. Refinish painted surfaces damaged during construction to match the rest of the panelboard.

END OF SECTION 262416

SECTION 262716 - CABINETS AND ENCLOSURES

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Indoor enclosures.
- B. Weatherproof enclosures.

1.14 RELATED SECTIONS

- A. Equipment foundations: Section 260528.

1.30 SUBMITTALS

- A. Comply with Division 01 and Section 260101.
- B. Product data: Each type of enclosure required for the project.

PART 2 - PRODUCTS

2.11 INDOOR ENCLOSURES

- A. Type 1 in accordance with NEMA 250 and conforming to UL 57, of size required by NEC to fit equipment or as shown on the drawings.
- B. Construction: Code grade galvanized steel.

2.12 WEATHERPROOF ENCLOSURES

- A. Type 3R in accordance with NEMA 250 and conforming to UL 57, of size required by NEC to fit equipment or as shown on the drawings.
- B. Construction: Fabricated of 14-gage galvanized steel, with drip shield top and smooth, seam-free sides and back.
- C. Doors: Double doors fabricated from 12-gage galvanized steel, overlap type without center post.
 - 1. Door gaskets: Neoprene, attached with oil-resistant adhesive and held in place with steel retaining strips.
 - 2. Full-length piano hinges.
 - 3. Locks: Keyed, with all keys alike. Provide two keys with each enclosure.
- D. Provide steel channels in rear of cabinet for mounting metering equipment.

2.13 FINISHES

- A. Satin gray enamel, inside and out.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Securely attach enclosure to wall on plywood backboard, set on housekeeping pad, or hang on frame, as indicated.

3.21 LOCATIONS

- A. Provide indoor type inside building and weatherproof type in exterior locations.

END OF SECTION 262716

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Receptacles.
- B. Emergency shutoff switches.
- C. Relays.
- D. Terminal blocks.

1.14 RELATED SECTIONS

- A. Nameplates: Section 260553.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data: Each type of device used in the project.
- C. Samples: One sample of each type of wiring device and device plate, if requested by Architect.

PART 2 - PRODUCTS

2.20 RECEPTACLES

- A. Acceptable manufacturers:
 - 1. Pass & Seymour, Inc.
 - 2. Leviton Manufacturing Co.
 - 3. Hubbell/Bryant Electric
 - 4. Cooper Industries/Cooper Wiring Devices.
- B. Provide devices conforming to UL 498 for receptacles, equal to the following Pass & Seymour catalog numbers or NEMA WD 1 and WD 6 configuration numbers:
 - 1. Duplex convenience receptacles:
 - a. Tamper resistant: TR5362, NEMA 5-20R.
 - b. Weatherproof cover: WIUC10FRED.
 - 2. GFCI receptacles: 2095, NEMA 5-20R.
 - a. Weatherproof cover: WIUC10FRED.
 - b. Exterior and wet locations: 2095TRWR, 20 amps, weather-resistant, tamper-resistant.
 - c. Interior cover: WP26 vertical, WPH26 horizontal.
 - 3. Duplex tamper-resistant receptacle with 2 USB charging ports: TR5362USB, 20 amps.
 - 4. Clock receptacles: S3733-SS.
 - 5. Dryer receptacles, plates and cords: 3864, 30 amp.

6. Kiln receptacle, NEMA 15-50R, 3 phase, 3W+grd: Hubbell Model HBL8450A, 50 amps.
7. Copier receptacle, NEMA 15-20R, 3 phase, 3W+grd: Hubbell Model HBL8420, 20 amps.
8. Range receptacle, NEMA 14-50R, 125/205V: 3894, 50 amps.

C. Device color:

1. General-purpose receptacles: Brown.
2. Computer/network receptacles: Gray.
3. Emergency power receptacles: Red .

D. Device plates: Equal to P&S: Type 302 stainless steel, SS Series.

1. Device plates for receptacles controlled by an automatic control device shall be custom engraved for metal, or pad printed for plastic, and shall identify the device with the words "Switched Receptacle".

2.21 EMERGENCY SHUTOFF SWITCHES

- A. Emergency switches to shut down equipment or circuits: Momentary-contact pushbutton station with normally open contact rated 240 V minimum, with red mushroom pushbutton.
- B. Gas-fired equipment shutdown: Surface-mounted enclosure with yellow cover and engraved nameplate: EMERGENCY BOILER SHUTDOWN.

2.25 RELAYS

- A. Relays: Equal to Square D Company, Class 8501 Type C in NEMA 250 type 1 enclosure.
- B. Contacts: Double-break, fine silver, convertible from normally open to normally closed contacts. Provide contact status indication.
- C. Coils: Molded construction, terminals provided with pressure wire connectors.
- D. Coil voltage and number of contacts shall be as indicated on the drawings.

2.30 TERMINAL BLOCKS

- A. Terminal blocks: Equal to Square D, screw-terminal type, size as required by NFPA 70, NEMA 250 Type 1 enclosure with hinged cover.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Install devices in complete compliance with the manufacturer's recommendations.
- B. Receptacles orientation:
 1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.
- C. 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.

- D. Arrangement of devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent devices under single multi-gang wall plates.

3.25 IDENTIFICATION

- A. Comply with Section 260553 "Identification for Electrical Systems."
- B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with white-filled lettering on back of plate, and durable wire markers or tags inside outlet boxes.
- C. Attach nameplates securely to receptacle cover plates. Provide nameplates for all devices except 120-volt receptacles, identifying equipment and use.

END OF SECTION 262726

SECTION 262800 - LOW-VOLTAGE CIRCUIT PROTECTIVE DEVICES

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Enclosed switches (disconnects/safety switches).
- B. Enclosed circuit breakers.
- C. Elevator disconnecting switch.

1.14 RELATED SECTIONS

- A. Motors: Sections 220513 and 230513.
- B. Fuses: Section 262813.

1.20 REFERENCES

- A. NEMA AB 1: Molded Case Circuit Breakers and Molded Case Switches.
- B. NEMA KS 1: Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
- C. UL 98: Enclosed and Dead-Front Switches.
- D. UL 489: Molded Case Circuit Breakers and Circuit Breaker Enclosures.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data: Each type of enclosed switch, enclosed circuit breaker, and elevator disconnecting switch.

1.40 QUALITY ASSURANCE

- A. Comply with the following standards:
 - 1. NEMA KS 1 for enclosed switches.
 - 2. UL 98.
 - 3. UL 198E
 - 4. UL 489 for enclosed circuit breakers.
- B. UL label and local testing (if required): As specified in Section 260500, Common Work Results for Electrical.

PART 2 - PRODUCTS

2.21 ENCLOSED SWITCHES (DISCONNECTS/SAFETY SWITCHES)

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

1. Eaton Corp; Cutler-Hammer Products
 2. General Electric Company
 3. Square D Company; Schneider Electric
- B. Properly size switches for number of poles and provide fused or non-fused as required for project conditions and to meet NFPA 70 requirements.
1. Neutral kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 2. Auxiliary contact kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
- C. Fuse contacts and quick-make/quick-break jaws shall insure positive contacts with reinforcing spring clips or other approved means.
- D. Switches shall be front-operated.
- E. Current-carrying parts: Silver-plated copper.
- F. Hinges: Noncurrent-carrying.
- G. Switches shall be lockable in either open or closed position.
- H. Type:
1. Nonfused switches: General-duty type on 120/208 V or 120/240 V systems, and heavy-duty type on 277/480 V or 240/480 V systems.
 2. Fused switches: Heavy-duty type on all voltages.
- I. Enclosures: Indoors NEMA 250 Type 1; outdoors Type 3R with raintight hubs.

2.22 ENCLOSED CIRCUIT BREAKERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Corp; Cutler-Hammer Products
 2. General Electric Company
 3. Square D Company; Schneider Electric
- B. Separately enclosed circuit breakers, as indicated, manually operated, trip-free from the handle, and provided with inverse-time, thermal-element overload protection and instantaneous magnetic short-circuit protection on all poles.
- C. Breaker sizes, calibrations and interrupting capacity: Noted on the drawings. Breakers shall be calibrated for 50 degrees C ambient and shall be rated for use with minimum 75 degree C wire.
- D. Type: Molded-case, NEMA AB 1.
- E. Operating handles shall clearly indicate the positions On, Trip, and Off.
- F. Provide shunt trip operation where indicated on the drawings.

- G. Unit shall be UL listed for service entrance where indicated on the drawings.
- H. Enclosures: Indoors NEMA 250 Type 1; outdoors Type 3R with raintight hubs.

2.23 ELEVATOR DISCONNECTING SWITCH

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Cutler-Hammer
 - 2. Cooper Bussmann, Inc.
 - 3. Mersen
 - 4. Littlefuse, Inc.
- B. Separately enclosed in NEMA 250 Type 1 enclosure with externally operable lockable handle allowing switch to be locked in the OFF position ensuring load side power isolation during servicing.
 - 1. Properly sized Class J fuses, equal to Cooper Bussmann JKS Limitron fuses, Class J fuse block, connected in series with molded case safety switch.
 - 2. Properly sized molded case switch, with 24 VDC shunt trip operation, connected in series with fuses.
 - 3. Control circuit: 120-Volt.
 - a. Control power transformer: Primary voltage as required for the motor, 120V secondary voltage; capacity to operate control devices and 100 percent spare capacity.
 - b. Primary and secondary fuse protection for each control power transformer: Class CC fuses, current-limiting rejection type, rated 0.1 to 30 A, 600 V, and 200 kA interrupting rating.
 - 4. Fire safety interface isolation relay: 3PDT, 10A, 120V relay with coil voltage as required to interface with the fire alarm system.
 - 5. Voltage monitoring relay: To monitor shunt trip voltage.
 - 6. Auxiliary control contacts:
 - a. One normally open and one normally closed primary auxiliary contact.
 - b. One normally open and one normally closed secondary auxiliary contact.
 - 7. Green power ON pilot light.
 - 8. Ground lug.
 - 9. Key-to-Test Switch.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Install enclosed switches where indicated and as required for motor outlets, transformers, and other equipment.
- B. Securely attach and properly connect enclosed switches, enclosed circuit breakers, and elevator disconnecting switches.

- C. Provide an enclosed switch for each motor, as required by NFPA 70, except where it is provided in a panelboard within sight and easy reach of the motor, and provide wiring and connections from source. Enclosed switches shall be fused where protection is required or indicated on drawings and unfused elsewhere.

- D. Enclosed switches:
 - 1. Provide neutral kit where required for four-wire application.
 - 2. Provide auxiliary contact kit where indicated on drawings.

END OF SECTION 262800

SECTION 262813 - FUSES

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Fuses.
- B. Spare fuse cabinet.

1.14 RELATED SECTIONS

- A. Motors: Sections 220513 and 230513.
- B. Disconnecting switches: Section 262800.

1.20 REFERENCES

- A. UL 198E: Class R fuses.
- B. UL 198C: High-Interrupting-Capacity Fuses, Current Limiting Types.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data: Each type of fuse.
- C. Published data on fuses shall include time/current curves, peak-let-through curves and I^2t melting and clearing curves.

1.40 QUALITY ASSURANCE

- A. Comply with UL 198C, Class L fuses, also Classes G and J.
- B. UL label and local testing (if required): As specified in Section 260500, Common Work Results for Electrical.

1.92 EXTRA MATERIALS

- A. Provide ten percent spare fuses, minimum three spare fuses, for each type fuse in the work.

PART 2 - PRODUCTS

2.20 FUSES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Bussmann, Inc.
 - 2. Ferraz Shawmut Inc.
 - 3. Littelfuse, Inc.

- B. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
- C. Fuses 0-600 amps for 600 V or 250 V, UL labeled Class RK1 with time delay, with a minimum short-circuit interrupting capacity of 200,000 rms symmetrical amperes, and shall carry 500 percent of rating for a minimum of 10 seconds.
 - 1. Fuses for disconnecting switches for packaged HVAC equipment: Size and type recommended by the equipment manufacturer and as required for equipment to meet UL rating.
- D. Fuses 601 amps and larger shall be UL labeled Class L with time delay, 600 V, with minimum short circuit interrupting capacity of 200,000 rms symmetrical amperes and dimensions to properly mount in switchboard or disconnecting switches.

2.21 SPARE FUSE CABINET

- A. Cabinet for spare fuses: 12-gage steel, with hinged lockable door. Provide space for spare fuses required in "Extra Materials" in Part 1 above.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Install fuses where indicated and as required for motor outlets or other equipment.
- B. Securely attach spare fuse cabinet to wall adjacent to the switchboard, where indicated on the drawings or in a convenient location selected by Owner's representative.

END OF SECTION 262813

SECTION 262914 - ENCLOSED MOTOR CONTROLLERS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Alternating-current motor starters (enclosed controllers) rated 600 V and less that are supplied as enclosed units.
 - 1. Magnetic motor starters and combination starters.
 - 2. Manual motor starters.

1.14 RELATED SECTIONS

- A. Motors and variable-frequency drives: Sections 220513, 230513, and 262923.
- B. Fuses: Section 262813.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data:
 - 1. Each type of motor starter included in the project, including dimensions, ratings, and data on features and components.
- C. Shop drawings: Composite wiring diagram showing the interlocking and control wiring.
- D. Operation and maintenance data: For operating and maintenance manuals, as specified in Section 260101.

1.40 QUALITY ASSURANCE

- A. Source limitations: Obtain motor starters of a single type through one source from a single manufacturer.
- B. Electrical components, devices, and accessories shall be listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to the authorities having jurisdiction, and marked for intended use.

1.49 COORDINATION

- A. Coordinate layout and installation of motor starters with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for work space and for access.
- B. Coordinate features, accessories, and functions of each motor starter with ratings and characteristics of supply circuit, motor, control sequence, and duty cycle of motor and load.
 - 1. Refer to wiring diagrams required in the sections specifying the equipment.

PART 2 - PRODUCTS

2.01 MOTOR STARTERS, GENERAL

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified Square D Company (Schneider Electric) products, or comparable products by one of the following:
1. Eaton Corp.; Cutler-Hammer Products
 2. General Electric Company
 3. Square D Company (Schneider Electric)

2.20 MAGNETIC MOTOR STARTERS

- A. Enclosure: Surface-mounted, NEMA 250 Type 1, unless otherwise indicated.
1. Outdoor locations: Type 3R.
 2. Kitchen areas: Type 4X, stainless steel.
 3. Wet or damp locations other than kitchens: Type 4.
 4. Hazardous areas indicated on drawings: Type 7C.
- B. Motor starters and combination starters shall be across-the-line magnetic type, equal to Square D Company, Class 8536, Type S, rated in accordance with NEMA Standards, sizes, and horsepower ratings.
1. Contacts: Double-break silver-alloy type, replaceable from the front without removing power wiring or removing the starter from its mounting.
 2. Overload protection: Solid-state overload relay, one-piece construction, interchangeable, with reset button set in cover.
 - a. Sensors in each phase: Matched to nameplate full-load current of the motor to which they connect and with appropriate adjustment for duty cycle.
 3. Starter shall operate only when protective relays are in place.
 4. Combination starters shall be lockable in the Off position.
 5. Disconnecting switch for combination starters: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Interlock with unit cover.
- C. Control circuit: 120-Volt.
1. Control power transformer: Primary voltage as required for the motor, 120-V secondary voltage; capacity to operate connected indicating and control devices and 100 percent spare capacity.
 2. Primary and secondary fuse protection for each control power transformer: Class CC fuses, current-limiting rejection type, rated 0.1 to 30 A, 600 V, and 200 kA interrupting rating.
- D. Auxiliary control contacts:
1. One spare normally open and one spare normally closed.
 2. Additional contacts required by the automatic temperature control system.
- E. Selector switches, indicating lights, and identification on each motor starter cover, complete with wiring and interconnections to starter and auxiliary control contacts:
1. Selector switch: Hand-Off-Automatic (HOA), heavy-duty.

2. Indicating lights: Push-to-test, 30.5 mm or 22 mm, transformer type, LED or neon.
Indications:
 - a. Red for Stopped and green for Running.
3. Identification: Printed or engraved nameplates for HOA switch and for each indicating light.

2.21 MANUAL MOTOR STARTERS

- A. Enclosures: NEMA 250 Type 1 for interior use and NEMA 250 Type 3R for exterior or damp or wet locations.
 1. Mounting: Flush-mounted in finished areas and where possible; surface-mounted elsewhere, with cover plates to suit the mounting.
 2. Indicating lights mounted in enclosure.
 3. Engraved plastic identification plates.
- B. Manual motor-starting switch: Equal to Square D Class 2510, single- or two-pole as required, with built-in thermal overload protection.
- C. Switch: Toggle, quick-make and quick-break, with self-indicating, trip-free handle, and means for locking in Off position.
- D. Overload protection unit: Melting-alloy type, interchangeable; starter shall be inoperative if unit is removed.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. For equipment at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For equipment not at walls, mount on lightweight structural-steel channels bolted to floor or to structure above ceiling.
- B. Provide wiring as indicated on the drawings.
- C. Applications: Magnetic motor starters for all equipment unless otherwise specified or indicated on drawings.
- D. Install starters, auxiliary contacts, and automatic control devices furnished with equipment, except those that are already mounted on the equipment, fully wired and connected. See coordination requirements specified in Part 1 above.
- E. Check the size of the overload protection, and change or adjust it as required, after the HVAC systems have been adjusted and balanced as specified in Section 230593, Testing, Adjusting, and Balancing.

Install fuses in each fusible switch. Comply with requirements of Section 262813.

END OF SECTION 262914

SECTION 262923 - VARIABLE FREQUENCY DRIVES

PART 1 – GENERAL

1.11 SECTION INCLUDES

- A. Variable frequency drives, rated less than 600V, for speed control of three-phase, induction motors.

1.14 RELATED SECTIONS

- A. Sections specifying requirements for LEED rating and commissioning are specified in Division 01.
- B. Motors: Section 230513.
- C. Pumps: Section 232123.
- D. Air-handling units: Section 237322.
- E. Energy recovery and dedicated outdoor air units: Section 237200.
- F. Controls: Sections 230901 through 230923.

1.20 REFERENCES

- A. ANSI/IEEE 399: Standard Practice for Industrial and Commercial Power Systems Analysis
- B. ANSI/IEEE 519: Standard Practices and Requirements for Harmonic Control in Electric Power Systems
- C. NEMA: Application Guide for AC Adjustable Speed Drive Systems
- D. NEMA ICS 61800-2: Adjustable Speed Electrical Power Drive Systems
- E. NEMA ICS 7.0: Industrial Controls & Systems for Adjustable Speed Drives
- F. NEMA ICS 7.1: Standard Standards for Construction and Guide Selection, Installation, and Operation of Adjustable Speed Drive Systems
- G. NEMA MG 1: Motors and Generators
- H. NETA ATS: Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems
- I. NFPA 70: National Electrical Code
- J. UL 508: Standard for Industrial Control Equipment
- K. UL 508C: Standard for Safety for Power Conversion Equipment

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.

- B. LEED submittal:
 - 1. Product data:
 - a. Energy and Atmosphere (EA), Credit 1: For optimize energy performance.
 - b. Energy and Atmosphere (EA), Credit 5: For continuous metering equipment for energy consumption.
- C. Product data: For each type and rating of equipment, include electrical ratings, operating characteristics, manufacturers' technical data on features and functions, enclosures, and furnished accessories. Include product data for each of the following:
 - 1. Variable frequency drive (VFD).
 - a. List rated capacities and relationship to motor values including voltage, horsepower, rated current, and short-circuit ratings.
- D. Bill of materials: Provide detailed list of components.
- E. Shop drawings: For each type of unit, indicate the following:
 - 1. Dimensioned plans, elevations, and sections; weights; loads; required clearances; mounting arrangements; components; and location of each field connection.
 - 2. List of installed device and related equipment ratings and features including:
 - a. Unit type and standard details
 - b. Enclosure type
 - c. Nameplate and identification labels
 - d. Factory settings of installed devices
 - 3. Wiring diagrams: Power, signal, and control wiring.
- F. Source quality-control test reports.
- G. Field quality-control test reports.
- H. Operation and maintenance data: For each type of variable frequency drive and associated components, include in operation and maintenance manuals. In addition to items specified in Division 01, include the following:
 - 1. Detailed operating and programming instructions.
 - 2. Troubleshooting procedures.
 - 3. Detailed spare parts list.
 - 4. Warranty, executed and signed at the time of putting the unit in service.
- I. Harmonic Analysis Study and Report: Certify compliance with IEEE Standard 519 and NETA Testing requirements:
 - 1. Identify the effects of nonlinear loads and their harmonic contribution to the electrical distribution system.
 - 2. Provide detailed harmonic analysis showing total harmonic voltage and total harmonic current distortion values. Utilize project specific equipment and conditions
 - 3. Provide recommendations to limit harmonic distortion at defined system locations.
 - 4. State methods, techniques, and products implemented to mitigate system harmonics.

1.40 QUALITY ASSURANCE

- A. Comply with requirements for LEED certification and commissioning specified in Division 01.
- 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; listed as a complete assembly.
 - 1. UL label and local testing (where required): As specified in Section 260500, Common Work Results for Electrical.
- C. Variable frequency drives shall be fully assembled, inspected, and tested at the factory prior to shipment.
- D. Installer qualifications:
 - 1. Staff is authorized and factory-trained by manufacturer. Includes training in electrical safety as required by NFPA 70E and qualified as defined in NEMA PB 2.
 - 2. Maintains a service center location with staff factory-trained by manufacturer in the Baltimore/Washington, DC, metropolitan area.
 - 3. Service available 24 hours a day, seven days a week, 365 days a year.
 - 4. Maintains an adequate stock of manufacturer's genuine or approved parts to service this equipment.
 - 5. Service and maintenance contracts available.
- E. Testing agency qualifications: Member company of NETA or a nationally recognized testing laboratory (NRTL).
 - 1. Testing agency's field supervisor: Currently certified by NETA to supervise on-site testing.
- F. Comply with referenced standards and listings previously identified including IEEE 519, NEMA MG 1, UL 508C, and NFPA 70.
- G. Verify motor, drive, and load compatibility. Motors shall be inverter duty rated, per NEMA MG1.

1.49 COORDINATION

- A. Ratings and functions of each variable frequency drive unit shall be coordinated with associated motor and connected load including the following:
 - 1. Load requirements such as torque, speed, and horsepower.
 - 2. Motor and power supply characteristics.
 - 3. Control and operational sequences.
 - 4. Ambient, environmental, and physical conditions of installation location.
- B. Coordinate layout and installation of drive and associated components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access.
- C. Coordinate method and location for mounting equipment including size and location of housekeeping pads and structural channel supports.
- D. Coordinate location of underslab and overhead conduit.

- E. Coordinate with BAS for proper control and communications functions.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Store equipment indoors in clean dry space with uniform temperature to prevent condensation. Protect equipment from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.60 PROJECT CONDITIONS

- A. Environmental conditions: Variable frequency drive assembly and associated components shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient temperature: Minus 15 to plus 40 deg C.
2. Relative humidity: 5 to 95 percent, non-condensing.
3. Altitude: Sea level to 3300 feet (1000 m).

1.80 WARRANTY

- A. Special warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of drive unit and associated auxiliary components that fail in materials or workmanship within specified warranty period:

1. Warranty period: Two years from date of substantial completion.
2. Warranty shall include all parts and labor.

1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01 for Commissioning Requirements.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

1.91 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. Control power fuses: Six of each type and rating used.
2. Indicating lights: Six of each type installed.
3. Touchup paint: Three containers of paint matching enclosure finish, each 0.5 pint (250mL).

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide products manufactured by ABB, Inc. (Model ACH550), or comparable product by one of the following:

1. ABB, Inc.

2. Eaton Corporation; Cutler-Hammer Products
3. General Electric Company
4. Square D/Telemecanique, Schneider Electric
5. Yaskawa Electric America, Inc.

2.20 VARIABLE FREQUENCY DRIVES

- A. Description: Enclosed variable frequency, alternating-current (AC) motor controller assembly suitable for operation of inverter-duty, Design A and Design B, induction motors as defined by NEMA MG1. The drive shall be designed for variable torque applications.
1. Unit shall be a packaged assembly including power conversion components, disconnecting means, overcurrent and overload protection, bypass, and control components.
- B. Equipment ratings and design:
1. Ratings: VFD shall be sized to match the motor load type served. The motor current, voltage, and/or horsepower ratings are scheduled on the drawings. The following drive ratings shall also apply:
 - a. Input power characteristics: Unit shall be capable of continuous operation under the following conditions.
 - (1) Voltage variation: Plus 10 percent or minus 15 percent, nominal 208 VAC or 480 VAC.
 - (2) Frequency variation: Plus or minus 5 percent, 60Hz.
 - (3) Power factor (input-primary side): 0.95 minimum.
 - b. Output power characteristics: 0 to Rated Input Voltage, 3-phase, 0 to 120 Hz.
 - (1) Current: Drive shall be capable of continuous operation at rated full load motor current.
 - (2) Power factor (output-secondary side): 0.90 minimum.
 - c. Minimum efficiency: 95 percent at half speed; 97 percent at rated full speed.
 - d. Overload capability: 110 percent of the normal duty current rating for 60 seconds, and 130 percent for 2 seconds.
 - e. Short-circuit current (withstand) rating: Minimum 22 kA, without additional input fuses, or available fault current value determined by short circuit analysis, whichever is greater.
 - f. Audible noise: Motor and VFD combination noise level shall not be increased more than 2 dBA at 3 feet (1m), compared to motor operation from across-the-line motor control.
 - g. Output carrier frequency: Unit shall have adjustable frequency switching settings up to 12 kHz without derating the drive output characteristics. Drive selection size may be increased to comply.
 2. Design: Unit shall consist of the following components and characteristics:
 - a. Power conversion components: Microprocessor based control.
 - (1) Rectifier: Solid state, full-wave, diode-bridge rectifier used to convert AC input power to DC power, with metal-oxide-varistor (MOV) surge protection.
 - (a) Provide 6-pulse drives with harmonic filters.

- (2) DC bus: DC-bus reactor and capacitor components to minimize reflected harmonics and manage DC power to inverter. Bus shall interface with VFD programmable logic controller, for continuous monitoring and protection of system components, and include short circuit protection and filtering.
 - (3) Inverter: Insulated-gate-bipolar-transistor (IGBT) type employing pulse-width-modulated (PWM) technology power supplies for sine-code, AC output waveform.
 - b. Standard power conditioning components: Provide the following power conditioning and filter devices.
 - (1) Integral, DC link reactor.
 - (2) Integral, 3-phase, EMI/RFI filter capable of filtering out radio frequency interference (RFI) in the range of 10 kHz to 30 MHz.
- C. Construction:
 1. Enclosure: UL (NEMA 250) Type 1 according to UL 508; as scheduled on the drawings.
 2. Completely assembled and tested by the manufacturer. Listed and labeled as a complete assembly under UL 508C.
 3. Furnish each unit with a master nameplate, listing standard manufacturer information including voltage, ampacity, frequency, and short-circuit ratings; manufacturer's model and project designations.
- D. Drive features:
 1. System interface
 - a. Digital display and keypad operator station sealed and located on front of assembly.
 - (1) Operator interface shall provide complete programming, program copying, operating, monitoring, and diagnostic capabilities.
 - (2) Operator interface shall include menus and selections to display system characteristics such as metering, program parameters, settings, and messages. Standard displays shall include:
 - (a) Output frequency (hertz).
 - (b) Set-point frequency (hertz).
 - (c) Motor current (amperes).
 - (d) DC-link voltage (volts-dc).
 - (e) Motor torque (percent).
 - (f) Motor speed (rpm).
 - (g) Motor output voltage (volts).
 - (h) Historical Information: Displays indicating current time and date, total run time, total power versus time log, and fault log.
 - (3) Keypad shall include Hand-Off-Auto selections in addition to programming and control keys.
 - (4) Security access: Capable of preventing access by unauthorized personnel and protecting data and system parameters.
 - b. System input characteristics capable of accepting remote signals from the Building Automation System (BAS) shall include the following:
 - (1) Minimum of six programmable, multifunction digital inputs.

- (2) Minimum of two programmable analog inputs accepting current or voltage signals for speed reference.
 - (3) Minimum of one external fault input, programmable for normally open or normally closed contact, used for connection of freeze, fire, smoke contacts, or high pressure limits.
 - c. System output characteristics including the following:
 - (1) Minimum of three programmable, multifunction, digital, Form-C type, relay outputs.
 - (2) Minimum of two programmable analog outputs.
 - (3) Programmable loss-of-load, Form-C type, relay output dedicated to drive protection under motor failure condition.
 2. Building automation system (BAS) interface: Factory-installed [or optional card] hardware and software package to enable the BAS to monitor, control, and display VFD status, alarms, and energy usage.
 - a. Network communications: Ethernet based with RS-422/RS-485 communication port.
 - b. Integral or removable communications card embedded with standard BAS protocols including Johnson Controls, Modbus, Siemens Building Technologies, and BACnet. Additional protocols such as LonWorks, DeviceNet, Ethernet TCP/IP, and Profibus shall be available with the addition of an optional card.
 3. Provide separate terminal strip and four auxiliary contacts for connection to remote device providing remote start/stop signals. All interlocks and start/stop contacts shall remain functional whether the drive is in Hand, Auto, or Bypass.
 4. Local Communication Port: RS-232 or USB 2.0 for connection of portable computer or peripheral device.
 5. Cooling fans: VFD shall incorporate cooling fan system to dissipate heat from assembly to maintain drive temperature control.
 6. Control power for drive controls as well as digital inputs and outputs shall be derived from internal power supply or control system power source.
- E. Drive functions: The VFD shall include the following functions, either pre-programmed or field-programmed according to project requirements.
1. Minimum of three programmable preset speeds.
 2. The ability to automatically reset and restart after an overcurrent, overvoltage, undervoltage, or over-temperature condition; overload fault; loss of phase, or loss of input signal.
 3. Capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to programmed set point without drive tripping or component damage.
 4. Capable of adjusting acceleration and deceleration ramp control time from 1 to 360 seconds.
 5. Equipped with an automatic extended power loss ride-through circuit which will utilize the inertia of the load to keep the drive powered. Minimum power loss ride-through shall be 12 cycles (200 milliseconds), based on full load and no inertia. Control logic shall incorporate programmable ride-through with minimum one-second (60 cycles).
 6. Stop modes shall be field-selectable allowing the VFD to ramp or coast to a stop.
- F. Drive and motor protection: Include the following electrical protection and safety features, factory mounted and wired within the VFD enclosure.
1. Input disconnecting means and overcurrent protective device: Integral, NEMA AB1, thermal magnetic, molded-case circuit breaker, with door interlocked, padlockable handle mechanism connected to input line side of drive.

- a. Circuit breaker shall be selected to provide trip-free operation. Breaker trip size and thermal curve shall be selected to allow VFD to operate the motor under continuous running and starting conditions as recommended by the motor manufacturer.
 - b. Service personnel shall be able to circumvent the main power disconnect and open the bypass enclosure without disconnecting power. A specific tool and mechanism shall be provided to accomplish this occurrence while meeting all code and safety requirements.
2. Transient voltage surge suppression (TVSS): Integral, system to provide three-phase protection against damage from supply voltage surges.
 3. Motor and VFD overload and overtemperature protection: NEMA ICS 2, solid-state, overload relay protection monitoring both motor and VFD characteristics. Relay shall be interconnected with motor thermal couple.
 4. Protective relays or functions for the following conditions:
 - a. Overvoltage
 - b. Undervoltage
 - c. Phase loss
 - d. Phase reversal
 - e. Ground fault
 5. Programmable, critical frequency lock-out: Multi-range selection, preventing VFD from operating load continuously at an unstable speed.
 6. Control fuses utilized within the drive enclosure shall be 100,000 A current limiting type. Input AC power fusing is not acceptable.

G. Comply with requirements of NEMA ICS 7, NEMA ICS 61800-2, and UL 580C.

2.21 DRIVE CONTROL AND OPERATION

A. VFD shall operate according to the following scenarios:

1. "Hand": VFD shall start and speed controlled manually through user interface.
2. "Off": VFD shall stop or disregard start signal.
3. "Auto": VFD shall start via external contact closure or control signal reference.

B. VFD shall run at programmable preset speed if input reference signal is lost.

2.22 DRIVE ISOLATION AND BYPASS

A. Description: Unit shall include mechanically and electrically interlocked bypass feature to isolate drive from the motor manually or automatically. Isolating switch arrangement shall be non-load break to isolate drive while motor is operating in bypass mode. Assembly shall be pre-wired and interconnected with drive unit. Bypass shall include contacts, separate [thermal] [solid-state] motor overload relay protection, circuit breaker disconnect, control transformer, controller, and selector switches required for complete bypass operation.

B. Bypass controller: Two-contactor-style arranged to isolate the power converter and permit safe troubleshooting and testing while motor is operating in bypass mode.

1. Bypass contactor: Load-break, IEC or NEMA rated.
2. Output Isolating Contactor: Non-load-break, IEC or NEMA rated.
3. Isolating Switch: Non-load-break switch, pad-lockable, door mounted handle mechanism.

- C. Bypass configuration: NEMA ICS 2, full-voltage (across-the-line) or reduced-voltage (as scheduled), non-reversing type, providing control of motor in bypass or test mode. A Drive/Off/Bypass/Test multi-position selector switch shall control the bypass contactor and the drive output contactor and be mounted on the enclosure door. LED indicator lights shall be mounted on enclosure door designating the following conditions:
 - 1. "Drive": The bypass contactor is open and the drive output contactor is closed. The motor is operated at the adjustable speed delivered from the drive.
 - 2. "Off": Contactors are open. The motor is disconnected from the bypass and drive.
 - 3. "Bypass": The drive output contactor is open, and the bypass contactor is closed. The motor is operated at full speed from the bypass starter at AC line voltage and frequency. The drive power is disconnected and can be serviced.
 - 4. "Test": The drive output contactor is open, and the bypass contactor is closed. The motor is operated at full speed from the bypass starter at AC line voltage and frequency. Drive remains connected to input power source for operational test while motor is running in bypass.
- D. Bypass and VFD shall be rated as single package, UL tested and listed.
- E. The drive output contactor shall open when a stop command is given, isolating the motor from the drive. Start/stop signals and safety interlocks shall work in both drive and bypass modes.
- F. Bypass shall incorporate applicable functions and protective features as previously listed for drive unit.

2.90 SOURCE QUALITY CONTROL

- A. Test and inspect variable frequency drive units and associated controls according to requirements in NEMA ICS 61800-2 and UL 508C.
 - 1. Perform tests at rated full load to ensure proper operation.
 - 2. Provide three certified copies of factory test reports.
- B. Each drive shall undergo a burn-in test at 100 percent inductive or motor load prior to final testing.

PART 3 – EXECUTION

3.02 EXAMINATION

- A. Examine project submittals for compliance with electrical distribution system requirements outlined on the drawings and in electrical specification sections.

3.03 SYSTEM DATA COLLECTION

- A. The Contractor shall gather and furnish data required to perform the harmonic system analysis study. The Engineer performing the analysis shall provide the Contractor with a listing of required data immediately after award of the contract. The Contractor shall expedite collection of the data to ensure completion of the study as required for final approval of the equipment submittals and/or prior to the release of the equipment for manufacturing.
- B. Input data is available on applicable electrical and mechanical drawings, system riser diagrams, equipment schedules, and from manufacturer's technical product literature and shop drawings. Required information may include system voltages and load currents, available short circuit current; transformer or other system impedances; motor and generator ratings; and lengths, sizes, and configurations of system distribution components.

- C. Where applicable, include harmonic contribution of significant existing building loads in the study. The Contractor shall obtain required existing equipment data to satisfy the study requirements.
- D. Tabulate input data necessary to support each study.

3.04 HARMONIC ANALYSIS STUDY

- A. Perform a harmonic analysis study to identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible operating scenarios, and include recommended harmonic mitigating techniques to limit voltage and current total harmonic distortion levels.
- B. System harmonic flow analysis shall be based on electrical power information to ensure compliance with IEEE 519. The Contractor shall provide data required to perform the analysis. Analysis shall be performed from point(s) of common coupling (PCC), which is defined as the primary side of the utility service entrance transformer in normal power system mode, and the standby generator source in emergency power system mode. Analysis shall be computer generated and summarize the current and voltage levels of harmonics up to the 50th level at the PCC.
- C. Actual job site measurement testing shall be conducted at full load and documented in the operation and maintenance manuals. Harmonic measuring equipment utilized for certification shall carry a current calibration certificate. The final test report shall be reviewed and compliance certification stamped by a licensed professional engineer. Text and graphical data shall be supplied showing voltage and current waveforms, THD and individual harmonic spectrum analysis in compliance with the above standards.
- D. Comply with requirements of IEEE 399 and NETA ATS.

3.20 INSTALLATION

- A. Install drive units in locations shown on drawings. Equipment shall not be located further from the equipment it serves than the maximum distance recommended by the drive manufacturer.
- B. Install wiring between drive and motor in ferrous metallic conduit, with separate conduits for power input, power output, and control wiring.
 - 1. Maintain minimum separation between conduits of 3 inches.
- C. Service engineers trained and authorized by the variable-frequency drive manufacturer at the service center shall provide start-up service, including physical inspection of drive and connected wiring and final adjustments to meet specified performance requirements.

3.59 IDENTIFICATION

- A. Materials: Refer to Section 260553 for requirements on identification of electrical systems. Identify units, devices, fuse blocks, relays, controls, and wiring. Identify equipment ratings.
- B. Nameplates: Refer to Section 260553 for requirements on identification of electrical systems. Provide nameplate for each drive unit and associated components located on front of assembly.
- C. Control components mounted within the assembly shall be identified corresponding to designations on manufacturer's drawings using tags and other identification materials.

- D. Operating instructions: Provide fabricated frame on side of each unit to house operating instruction manuals.

3.60 FIELD QUALITY CONTROL

- A. Test variable frequency drives by operating them in all modes with associated components and motors. Perform tests recommended by manufacturer under supervision of manufacturer's factory-authorized representative. Tests shall include simulation of various building conditions through the BAS control system.
- B. Coordinate tests with system balancing of fan and pump equipment.
- C. Perform mechanical and visual inspection of equipment installation including verification of wiring and components, connections, enclosures, and auxiliary devices and components.
- D. Perform testing in compliance with NETA ATS. Perform manufacturer standard tests including the following:
 - 1. Test insulation resistance and circuit continuity for power and control wiring.
 - 2. Verify voltage values follow nameplate ratings at drive input and output terminals.
- E. Correct deficiencies and retest equipment until equipment is operational. Report results and identify corrections in writing. Where necessary, replace damaged and malfunctioning equipment.
- F. Record field adjustable settings.
- G. Harmonic testing:
 - 1. Actual job site measurement testing of harmonics shall be conducted at full load and documented in the operation and maintenance manuals.
 - 2. Documentation of power quality compliance shall be part of the field quality control requirements.
 - 3. Harmonic measuring equipment utilized for certification shall carry a current calibration certificate.
 - 4. The final test report shall be reviewed and compliance certification stamped by a licensed professional engineer. Text and graphical data shall be supplied showing voltage and current waveforms, THD and individual harmonic spectrum analysis in compliance with IEEE 399 and 519 standards.

3.70 ADJUSTING

- A. Program variable frequency drives for required operations as outlined by the mechanical control sequences.
- B. Set field-adjustable elements such as switches, relays, timers, and trip devices as required for proper system operation and coordination with related power and control systems.

3.75 CLEANING

- A. Upon 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 the manufacturer.

3.80 SYSTEM STARTUP

- A. Provide factory-authorized service representative to perform startup service.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Sections 260500, provide operating instructions.
- B. Provide at least two sessions of four consecutive hours of additional instruction time for each system specified in this section.

END OF SECTION 262923

SECTION 263213 - GENERATORS, WEATHER-PROTECTED

PART 1 – GENERAL

1.11 SECTION INCLUDES

- A. Packaged engine generator set for standby, emergency power application including the following:
 - 1. Diesel engine with electronic generator set controls, governor, and voltage regulator.
 - 2. Located in outdoor, weather-protected, sound-attenuated enclosure.
 - 3. Complete with remote annunciator, sub-base fuel tank, and generator accessories.

1.14 RELATED SECTIONS

- A. Sections specifying requirements for commissioning are specified in Division 01.
- B. Grounding and bonding: Section 260526.
- C. Equipment foundations: Section 260528.
- D. Transfer switches: Section 263600.

1.20 REFERENCES

- A. ANSI/NECA/EGSA 404: Standard for Installing Generator Sets.
- B. CFR Title 40, Protection of Environment.
- C. IEEE 115: Test Procedures for Synchronous Machines.
- D. IEEE 446: Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications.
- E. NECA/EGSA 404: Standard for Installing Generator Sets.
- F. NEMA MG 1: Motors and Generators.
- G. NETA ATS: Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
- H. NFPA 30: Flammable and Combustible Liquids Code.
- I. NFPA 37: Installation and Use of Stationary Combustion Engines and Gas Turbines.
- J. NFPA 70: National Electrical Code.
- K. NFPA 110: Emergency and Standby Power Systems.
- L. UL 1236: Battery Chargers for Charging Engine Starter Batteries.
- M. UL 2200: Stationary Engine Generator Assemblies.

1.21 DEFINITIONS

- A. CFR: Code of Federal Regulations.
- B. EPA: Environmental Protection Agency.
- C. NIST: National Institute of Standards and Technology
- D. NSPS: New Source Performance Standards.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data: For each type of packaged generator set indicated. Include rated capacities, operating characteristics, manufacturers' technical data on features and functions, finishes, and furnished accessories. Include product data for each of the following:
 - 1. Engine generator set.
 - a. Thermal damage curve for generator.
 - b. Time-current characteristic curves for generator protective device.
 - c. Documentation proving that generator(s) provided have sufficient starting kVA to start the loads under any load sequence.
 - 2. Generator accessories including batteries and battery charger, silencer, anti-condensation heater, and jacket heater.
 - 3. Remote alarm annunciator panel.
 - 4. Enclosure components and accessories.
 - 5. Sub-base fuel tank.
- C. Bill of materials: Provide detailed list of components.
- D. Shop drawings: For each type of generator set and related equipment, detail assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
 - 2. Design calculations: Calculate requirements for designing vibration isolation bases.
 - 3. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
 - 4. Wiring diagrams: Power, signal, and control wiring.
 - 5. Piping schematics for fuel system, lubricating oil, jacket coolant, and cooling water.
- E. Source quality-control test reports.
 - 1. Certified summary of performance tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
 - 2. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
 - 3. Report of sound generation.
 - 4. Report of exhaust emissions showing compliance with applicable regulations.

- a. Factory certification of compliance with EPA emissions regulations.
- F. Field quality-control test reports.
- G. Operation and maintenance data: For packaged engine generator sets, accessories, and remote annunciator panel to include in operation and maintenance manuals. In addition to items specified in Division 01, include the following:
 - 1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
 - 2. Detailed operating instructions for event conditions.
 - 3. Fuel adjustment procedures and maximum tolerances of wear on bearings and other rubbing surfaces that will require corrective measures.
 - 4. Sub-base fuel tank.
- H. Warranty: Certificate of special warranty.
- I. Air quality permits: Submit air quality construction and operational permits for Owner record.

1.40 QUALITY ASSURANCE

- A. Generator accessories, appurtenances, and installation of the same, shall comply with referenced codes and standards listed in Part 1 and applicable federal, state, and local codes and regulations.
- B. Comply with requirements for commissioning specified in Division 01.
- C. Emissions: Equipment shall be certified to U.S. EPA Stationary Emission Regulation, 40 CFR, Part 60.
- D. Permits: Serve as the Owner's representative during the application process. Collect generator information, prepare and submit required applications for air quality construction and operational permits required by the State of Maryland Department of the Environment in compliance of state environmental regulations. Include payment for applicable permit costs. Approved permits and registration shall be issued to the Owner.
- E. Equipment shall bear UL label, and shall be locally tested by an electrical testing specialist, acceptable to local authority having jurisdiction where required.
- F. Source limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
- G. Installer qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this project.
 - 1. Installer has training in electrical safety as required by NFPA 70E and is qualified as defined in NEMA PB 2.
- H. 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), and that is acceptable to authorities having jurisdiction.

1. Testing agency's field supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

I. Service and maintenance agency qualifications: Manufacturer's authorized service and maintenance representative characteristics shall include the following:

1. Located in the Baltimore/Washington, DC metropolitan area.
2. Staff is factory employed and trained.
3. Service available 24 hours a day, seven days a week, 365 days a year.
4. Maintains an adequate stock of manufacturer's genuine or approved parts to service this equipment.
5. Service and maintenance contracts available.

1.49 COORDINATION

A. Obtain interconnection diagrams, interface hardware, accessory components, and installation manual for generator, and other components of the system. Coordinate installation to provide a complete, integrated, operating generator system.

1. Coordinate installation and interface connections with other emergency power supply system equipment.

B. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.60 PROJECT CONDITIONS

A. Environmental conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient temperature: Minus 15 to plus 40 deg C.
2. Relative humidity: 0 to 95 percent.
3. Altitude: Sea level to minimum 1000 feet (300 m).

1.80 WARRANTY

A. Special warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period:

1. Warranty period: Five years from date of substantial completion.
2. Warranty shall include all parts and labor with no deductible.

1.85 COMMISSIONING

A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01 for Commissioning Requirements.

B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

1.91 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. Fuses: One for every ten of each type and rating, but no less than one of each.
 - 2. Indicator lamps: One for every five of each type used, but no fewer than two of each.
 - 3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
- B. Provide fuel required for testing, re-testing, and demonstrations.
- C. Provide fuel to fill storage tank to rated capacity upon completion of work.

1.92 MAINTENANCE SERVICE

- A. Initial maintenance service: Beginning at Substantial Completion, provide, equal to warranty period, full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide products manufactured by Kohler Power Systems Co.; Generator Division (Model) 200REOZTF, or comparable product by one of the following:
 - 1. Caterpillar; Power Generation
 - 2. Cummins Power Generation/Onan
 - 3. MTU
 - 4. Generac
 - 5. Kohler Power Systems Co.; Generator Division

2.20 GENERATOR SET

- A. Generator set characteristics: The generator set system shall comprise of a package of equipment including:
 - 1. A diesel engine and alternator assembly to provide emergency electric power.
 - 2. Generator-mounted start-stop control system with remote control capability.
 - 3. Mounted accessories as specified.
 - 4. Factory-assembled and -tested, engine-generator set.
- B. Generator set ratings:
 - 1. Duty rating shall be based on emergency/standby service.
 - 2. Operate at 1800 rpm and 480/277 volts AC, 3-phase, 4-wire, 60 hertz.
 - 3. The generator set shall be rated at values indicated on the drawings at 0.8 pf based on the project conditions listed in Part 1.
- C. Performance characteristics:

1. The engine-generator set shall be able to handle the starting step load effects of the connected equipment.
2. Generator set characteristics shall not exceed the following:
 - a. Starting voltage dip: 30 percent.
 - b. Peak voltage dip: 15 percent.
 - c. Frequency dip: 15 percent.
 - d. Voltage regulation (no load to full load): Plus or minus 1 percent of rated output voltage.
 - e. Voltage regulation (random): Plus or minus 0.5 percent of rated output voltage.
 - f. Frequency regulation (steady-state): Isochronous.
 - g. Frequency regulation (random): Plus or minus 0.25 percent of rated frequency from no load to full load.
3. AC output waveform: Distortion at no load measured line-to-line or line-to-neutral.
 - a. Total harmonic distortion (THD): Less than 5 percent
 - b. Single harmonic: Less than 3 percent.
 - c. Telephone influence factor (TIF): Less than 50, as determined by NEMA MG 1.
 - d. Telephone harmonic factor (THF): Less than 3, as determined by IEC 60034.
4. Steady-state frequency stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Sustained short-circuit current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
6. Start time: Comply with NFPA 110, Type 10, system requirements.
7. Excitation system: Performance shall be unaffected by voltage distortion caused by nonlinear load.

D. Engine:

1. Diesel engine: Water-cooled inline or Vee-type, four-cycle, compression ignition diesel engine shall meet specifications when operating on No. 2 domestic burner oil. Diesel engines requiring premium fuels will not be considered. The engine shall be equipped with filters for fuel, lube oil, and in-take air; lube oil cooler; fuel transfer pump; fuel priming pump; and gear driven water pump.
 - a. The engine governor shall maintain frequency regulation as indicated in performance characteristics above.
 - b. Safety devices: Safety shutoffs for high water temperature, low oil pressure, overspeed, and engine overcrank.

E. Generator: Three-phase, single bearing, synchronous type built to NEMA MG 1 standards.

1. Alternator: Brushless, 4-pole, 2/3 pitch windings, 125 degrees C standard temperature rise. Class H insulation shall be used on the stator and rotor, and both shall be further protected with 100 percent epoxy impregnation and an overcoat of resilient insulating material on end coils to protect against fungus or abrasion. The generator shall incorporate a resettable thermal protector for exciter/regulator protection. The generator shall be twelve lead, wye connected.

- a. Accessory: Alternator anti-condensation space heater.
 2. Regulator: Permanent magnet excitation for power source to voltage regulators, solid-state controlled, exciter/regulator, matching the characteristics of the generator and engine. Voltage regulation with adjustable electronic isochronous governor. Readily accessible voltage droop, voltage level, and voltage gain controls shall be provided. The solid state regulator module shall be shock mounted and epoxy encapsulated for protection against vibration and atmospheric deterioration.
 3. The subtransient reactance of the alternator shall not exceed 12 percent, based on the standby rating of the generator set.
- F. Mounting:
1. Unit shall be capable of installation on rail system within enclosure base and include vibration isolation as required.
- G. Cooling system: Closed loop, liquid-cooled system with engine mounted radiator and blower type fan, sized to maintain safe operation at 104 degrees F (40 degrees C) maximum ambient temperature. The radiator shall be equipped for a duct adapter flange connected to exterior cabinet with flexible connection.
1. Centrifugal jacket water pump: Built on the engine and driven from the engine crankshaft or camshaft, ample capacity to circulate the required flow of engine jacket water through the radiator to remove the total heat rejected from the engine to the jacket water and lubricating oil at 110 percent rated load in 104 degrees F (40 degrees C) ambient while maintaining the optimum jacket water temperature leaving and entering the engine recommended by the engine manufacturer.
 2. Thermostatic control valve: Shall maintain constant water temperature to the engine. Provide modulating type thermostatic valves using self-contained thermostats without external bulbs. Provide valves with one or more interchangeable thermostatic elements. Provide nonadjustable type thermostat with operating temperature factory set at the temperature recommended by the engine manufacturer. Design valve so that in event of thermostatic element failure it will fail safe, permitting water flow through the engine.
- H. Fuel system: Diesel
1. Fuel oil system shall consist of the following tanks:
 - a. Sub-base fuel tank for generator set.
 2. Provide an engine mounted fuel filter, fuel pressure gauge, and integral engine fuel priming pump, completely piped from integral day tank to diesel engine.
 3. Provide generator with fuel-water separator.
 4. Conform to NFPA 30 and NFPA 37 and the requirements herein. Employ a mechanical fuel injection system using a common rail system or an individual pump system. Provide injection pumps as an integral part of the engine and driven by the engine camshaft. Provide suitable adjustments for timing and for balancing of cylinder pressures. Provide the following items:
 - a. A built on positive displacement fuel oil supply pump driven from the engine crankshaft or camshaft. Pump capacity shall suit engine requirements under the maximum load condition.
 - b. A suitable positive displacement fuel oil priming pump for priming the fuel system, if required, to ensure quick starting, and arranged to operate with the automatic starting system.

- c. Fuel oil filters in the piping ahead of the injection pumps. Provide generator unit with a parallel filter arrangement having built in changeover valves allowing either filter to be used independently. Filters shall have replaceable spin-on canister elements.

I. Exhaust system:

- 1. Provide a silencer, including flexible exhaust fitting, properly sized and installed according to the manufacturer's recommendation. Mounting shall be provided by the installing contractor. The silencer shall be mounted so that its weight is not supported by the engine.
 - a. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - (1) Minimum sound attenuation of 25 dB at 500 Hz.
 - (2) Sound level measured at a distance of 10 feet (3 m) from exhaust discharge after installation is complete shall be 85 dBA or less.
- 2. Exhaust pipe size shall be sufficient to ensure that exhaust backpressure does not exceed the maximum limitations specified by the generator set manufacturer.

J. Automatic starting system:

- 1. Starting motor: DC electric starting system with positive engagement drive. The motor voltage shall be as recommended by the engine manufacturer.
- 2. Automatic controls: Fully automatic generator set start-stop controls in the generator control panel. Controls shall provide shutdown for low oil pressure, high water temperature, overspeed, and overcrank; and one auxiliary contact for activating accessory items. Controls shall include a multi-cycle, cranking limit with lockout contacts for starting by switch on remote panel.

K. System accessories:

- 1. Jacket water heater: Unit mounted thermal circulation type water heater incorporating a thermostatic switch, capable of maintaining engine jacket water to 90 degrees F in ambient temperature of minus 10 degrees F. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.
- 2. Starting and station batteries: Lead-acid storage battery set of the heavy duty starting type. 24Vdc battery voltage shall be compatible with the starting system. The battery set shall be of sufficient capacity to provide for 1 1/2 minutes total cranking time without recharging. Include a battery rack and necessary cables and clamps.
- 3. Battery charger: UL 1236 listed. Engine starting, current limiting battery charger to automatically recharge batteries. The charger shall have adjustable float and equalize voltage. DC amperage output shall be no less than 10 amperes. Output voltage shall be compatible with starting system. AC input voltage shall be 120V. Charger shall include fused overload protection; circuit breaker overcurrent protection; solid-state, silicon diode full wave rectifiers; voltage surge suppressors; DC voltmeter and AC ammeter; temperature voltage regulator; relays indicating AC power failure, low-, and high-battery voltage.

L. Generator control panel:

- 1. Type: Generator mounted NEMA 250 Type 1, vibration isolated, dead front, made of sheet metal gauge steel, with lockable hinged door.
- 2. Panel shall contain, but not be limited to, the following equipment:

- a. Voltmeter, 2 percent accuracy.
 - b. Ammeter, 2 percent accuracy.
 - c. Ammeter voltmeter, phase selector switch.
 - d. Frequency meter, dial type. (45 - 65 Hz)
 - e. Automatic starting controls.
 - f. Voltage level adjustment rheostat.
 - g. Dry contacts for remote alarms wired to terminal strips.
 - h. Fault indicators for low oil pressure, high water temperature, overspeed, and overcrank.
 - i. Three position selector switch with the following functions: auto, manual, off/reset.
 - j. Emergency stop switch.
 - k. Panel light.
 - l. Running time meter
 - m. Oil pressure and water temperature gauges
3. Remote outputs for monitoring.
 4. Accessory: Anti-condensation space heater.
- M. Generator output circuit breakers:
1. Type: Molded-case circuit breaker, size as indicated on drawings. Circuit breaker shall conform to standards established by UL 489, and NFPA 70. Circuit breaker shall have long-time and short-time pick-up and delay, and instantaneous adjustable trip settings.
 2. The circuit breaker trip curve shall be coordinated with alternator thermal damage curve as required by generator manufacturer data.
 - a. Generator/exciter field circuit breakers do not meet the specified electrical standards and are unacceptable for line protection.
 3. Shunt trip device: The shunt trip shall open the generator circuit breaker in the event of an engine shutdown signal, and shall operate from the cranking battery voltage.
 4. Circuit breakers shall be lockable in the open position.

2.21 GENERATOR ENCLOSURE

- A. Manufacturer's standard enclosure: Prefabricated weather-resistant, sound attenuated enclosure sized to house the generator, sub-base fuel tank, battery charger, batteries, and required accessories. Enclosure shall be factory-assembled by the generator manufacturer.
- B. Sheet metal steel enclosure primed with corrosion protection and painted with electrostatically-applied powder coat finish of manufacturer's standard color. Enclosure shall include roof, side walls, and end walls. Hardware shall be stainless steel.
 1. Lifting provisions: Capacity to support total assembly weight during rigging.
 2. Access doors: Provide sufficient access for maintenance and operation from outside the enclosure.
 - a. Handles key lockable, all doors keyed alike.
 3. Air intake and sound attenuation louver openings shall be screened to limit entry of rodents.
 4. Roof shall be designed to prevent collection of rainwater.
 5. Provide factory-mounted exhaust silencer inside the enclosure. Exhaust shall exit the enclosure through a rain collar and terminate at a rain cap. Exhaust connections to the generator set shall be made with seamless flexible connections.

- C. Sound attenuation: Enclosure shall be constructed to mitigate noise level to 85 dBA maximum at 23 feet (7 m) from enclosure at rated generator output.
- D. Accessories:
 - 1. Enclosure manufacturer shall provide the hardware required to mount the exhaust silencers while maintaining the enclosure's weather resistance.

2.23 FUEL OIL STORAGE

- A. Comply with NFPA 30.
- B. Sub-base tank: Mounted in unit base, factory installed and piped in accordance with appropriate local codes and regulations, complying with UL 142. Provide the following features:
 - 1. Tank shall be designed and supplied as an engineered system meeting the requirements for the generator it serves, including inlet flow control devices, other valves, supply pumps, overflow return pump, level and pump controls, indicators, alarms, and other devices, in an integrated, operational system.
 - 2. Standards: System shall meet the applicable requirements of NFPA 30, 31, and 37, and UL 80 and 142, and shall be labeled in accordance with UL 142 and 508.
 - 3. Capacity: Based on 48 hours of continuous operation at 100 percent rated generator power output.
 - 4. Mounting: Sub-base tank sized and coordinated for placement between generator set mounting skids.
 - 5. Construction: Rectangular atmospheric tank, dual walled, steel, all welded, meeting requirements of the specified standards for outdoor use with fuel oil, and meeting factory leak test at 5 psi.
 - a. Base: Welded steel channels designed to be bolted to concrete foundation.
 - b. Cover: Removable, steel. Include inspection port.
 - c. Connections: ASTM A 53 Schedule 40, black iron, from the tank to engine as recommended by the manufacturer, each connection to fixed installed piping with unions permitting tank to be removed or serviced.
 - d. Fuel level gauge.
 - 6. Finishes, tank and containment basin:
 - a. Interior: Epoxy coating.
 - b. Exterior: Primed and painted with manufacturer's standard industrial black enamel finish.
 - 7. Inlet devices.
 - 8. Monitoring system: Provide contacts from base tank for monitoring by the power monitoring system for the following functions:
 - a. Tank alarms: high level, low level, overflow, tank leak.

2.30 VIBRATION ISOLATION DEVICES

- A. Elastomeric isolator pads: Oil- and water-resistant elastomer, arranged in single or multiple layers, molded with a non-slip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Double layer, standard neoprene.

2.31 REMOTE ALARM ANNUNCIATOR PANEL

- A. Surface-mounted panel, complying with the requirements of NFPA 110, Level 1 equipment, providing visible and audible alarm signals powered by the storage battery of the generator. Unit enclosure: Fabricated of sheet steel, with removable front panel. The front panel shall contain LED type indicating lamps (visible signals) as listed below. The enclosure shall contain the required printed circuits, internal wiring, terminal block and battery voltage sensors. Provide knockouts for external wiring through bottom of box.

- B. Provide on face of panel the following switches:
 1. Lamp test pushbutton.
 2. Audible alarm: Silence switch.

LAMP LEGEND	GENERATING SET CONDITION INDICATED	DERANGEMENT SIGNALS	
		Audible	Visible
EXERCISING	Generator exercising	No	Yes
GENERATING	Generating Power to Load	Yes	Yes
OVERCRANK	Failed to Start	Yes	Yes
LOW ENG TEMP	Low Lube Oil Pressure	Yes	Yes
HI ENG TEMP PRE	Excessive Engine Temperature Pre-Alarm	Yes	Yes
HI ENG TEMP	Excessive Engine Temperature	Yes	Yes
LOW OIL PRESS PRE	Low Lube Oil Pressure Pre-Alarm	Yes	Yes
LOW OIL PRESS	Low Lube Oil Pressure	Yes	Yes
OVERSPEED	Engine Overspeed	Yes	Yes
LOW FUEL	Low Fuel Supply	Yes	Yes
LOW COOLANT	Low Engine Coolant Level	Yes	Yes
AUTO SWITCH	Control Switch Not in Automatic Position	Yes	Yes
LOW CRANK VOLT	Low Engine Cranking Voltage	Yes	Yes
LOW BATT VOLT	Low Battery Voltage	Yes	Yes
HI BATT VOLT	High Battery Voltage	Yes	Yes
ALARM CONTACT	Contacts for Common Alarm	Yes	Yes

2.32 MONITORING SYSTEM

- A. Monitoring system: Provide contacts from generator for monitoring by the power monitoring system for the following functions:
 1. Generator off.
 2. Generator running.
 3. Generator exercising.

4. Generator alarms: Overcrank, low oil pressure, high or low engine temperature, overspeed, batteries.
- B. Provide control interface at the annunciator panel for monitoring the generator status through the building fire alarm system and building automation system.

2.40 SYSTEM OPERATION

A. Loss of normal power:

1. System is given signal to start by one of the automatic transfer switches or a remote device. Loss of power can occur at any automatic transfer switch, which can cause the generator to start. On receipt of this signal, generator shall automatically start, accelerate to rated frequency and build up to rated voltage.
2. Priority shall be set to actuate the automatic transfer switch designated in the following order:
 - a. ATS-1: Emergency
 - b. ATS-2: Optional standby.
3. After the first transfer switch closes to the bus, subsequent transfer switches shall close to the bus after pre-determined time delays.

B. Failure of generator to start:

1. If a unit fails to start, after the overcrank time delay (in the generator set control) has expired, the unit will be shut down, and an alarm will sound.

C. Return of normal power:

1. When normal power has been restored to the normal power system bus and sensed at each transfer switch, the loads shall be transferred back to normal source.
2. The generator shall operate until all transfer switches have returned to normal power switch position and operate at no load for a cool-down period. When the cool-down period has been completed, the generator shall shut down.
3. If a system start signal is received during the cool-down period, generator shall remain online and operate as described in "Loss of Normal Power" above.

2.90 SOURCE QUALITY CONTROL

A. Prototype testing: Perform factory performance tests using prototype generator of same engine model and alternative configuration, and assembled with like components and accessories. Provide three certified copies of the successful test reports.

1. Tests: Comply with NFPA 110, Level 1, energy converters in Paragraphs 3.2.1, 3.2.1.1, and 3.2.1.2.
2. Alternator tests: Comply with IEEE 115.
3. Equivalent components and accessories: Submit evidence that items furnished with the unit, but that are not identical to those on the prototype, are reliable and compatible with the application.

PART 3 – EXECUTION

3.02 EXAMINATION

- A. Examine rough-in requirements for connecting piping and wiring for generator and verify conditions. Verify actual sizes and locations of connections are correct before packaged engine-generator installation.

3.05 PREPARATION

- A. Battery equalization: Equalize charging of battery cells according to manufacturer's written instructions.

3.20 INSTALLATION – GENERATORS

- A. Install generators, complete with controls, accessories, sub-base tanks, and enclosure, as indicated on the drawings and in accordance with manufacturer's recommendations.
- B. Comply with generator manufacturer's written installation and alignment instructions and with NFPA 37 and 110.
- C. Install the remote alarm annunciator panel where indicated on drawings.
- D. Set generators plumb and level.
- E. Install generators so as to provide access for maintenance and service, including removal of drivers and accessories.
- F. Install piping, wiring, accessories, and appurtenances in accordance with the applicable specifications and manufacturers' recommendations. Ground equipment.
- G. Comply with applicable portions of NECA 404.
- H. Generator and enclosure accessories shall be connected to the building electrical distribution system via branch circuits and feeders as indicated on drawings.

3.59 IDENTIFICATION

- A. Materials: Refer to Section 260553 for requirements on identification of electrical systems. Identify units, devices, fuse blocks, relays, controls, and wiring. Identify equipment ratings.
- B. Nameplates: Refer to Section 260553 for requirements on identification of electrical systems. Provide nameplate for each unit and associated components located on front of assembly.
- C. Control components mounted within the assembly shall be identified with tags and other identification materials, and correspond to designations on manufacturer's drawings.
- D. Operating instructions: Provide fabricated frame on side of unit to house operating instruction manuals.

3.60 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.

1. Manufacturer's field service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections; and to assist the Contractor in testing.
- B. Tests and inspections:
1. Perform tests recommended by manufacturer. Perform electrical tests and visual and mechanical inspection for "AC Generators and or Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 2. NFPA 110 acceptance tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
 3. Battery tests: Record individual cell voltages.
 - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c. Verify acceptance of charge for each element of the battery after discharge.
 - d. Verify that measurements are within manufacturer's specifications.
 4. Battery-charger tests: Verify specified rates of charge for both equalizing and float charging conditions.
 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. Retain subparagraph below for long, restricted exhaust systems.
 6. Voltage and frequency transient stability tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
 7. Harmonic-content tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
 8. Noise level tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations, and compare measured levels with required values.
- C. Coordinate generator testing with tests for transfer switches and run them concurrently.
- D. 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.
- E. Leak test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- F. Operational test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- H. Remove and replace malfunctioning units; retest and reinspect as specified above.
- I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

- J. The unit shall operate without undue noise or vibration, or excessive heating. Correct defects and retest until unit is operating satisfactorily.
- K. Demonstrate satisfactory operation of each feature required of the generator set and accessories.
- L. Test emergency power system: After completion and acceptance of the generator tests, perform an operational test of the emergency power system. Perform a power failure test on the emergency electrical system. This shall be performed by interrupting the normal power source and verifying proper generator start and transfer switch operation.
- M. Report results of tests and inspections in writing. Record adjustable device settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.61 ACCEPTANCE TESTING

- A. In addition to the factory and field tests required in Part 2, perform a scheduled on-site test and demonstration of the completely installed generator before making final electrical connections.
- B. Test shall be witnessed by the Architect, Owner's representative, and manufacturer's representative. Manufacturer's representative shall conduct demonstrations.
- C. Provide and utilize load bank for testing. Load banks shall be capable of providing full load at 0.8 power factor.
- D. Test procedures: Test the generator in accordance with NFPA 110 and as follows:
 - 1. Test the generator for at least two hours under full load, starting and stopping at least five times.
 - a. The unit shall operate without undue noise or vibration, or excessive heating. Correct defects and retest until unit is operating satisfactorily.
 - b. Demonstrate satisfactory operation of each feature required of the generator set and accessories.

3.75 CLEANING

- A. Upon 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 the manufacturer.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 260500, provide operating instructions.

END OF SECTION 263213

SECTION 263600 - TRANSFER SWITCHES

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Transfer switches rated 600 V and less, including automatic transfer switch.

1.14 RELATED SECTIONS

- A. Sections specifying requirements for commissioning are specified in Division 01.
- B. Generators: Section 263213.

1.20 REFERENCES

- A. NFPA 110: Emergency and Standby Power Systems.
- B. UL 1008: Transfer Switch Equipment.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Shop drawings: Wiring diagrams showing detail wiring for transfer switch, differentiating between manufacturer-installed and field-installed wiring, and including power and control wiring.
- C. Product data: Include ratings and dimensioned plans, sections, and elevations showing minimum clearances, conductor entry, gutter space, installed features and devices, and material lists for each switch.
- D. Certifications:
 - 1. Product certificate signed by manufacturer certifying that products furnished comply with requirements and that switches have been tested for applicable load ratings and short-circuit closing and withstand ratings.
 - 2. Qualifications of manufacturer's representative.
- E. Operation and maintenance data: For each type of product to include in maintenance manuals specified in Division 01. Include all features and operating sequences, both automatic and manual. List factory settings of relays and provide relay-setting and calibration instructions, including software, where applicable.
- F. Source quality-control test reports.
- G. Field quality control test reports.

1.40 QUALITY ASSURANCE

- A. Automatic transfer switch shall comply with UL 1008. Where specified requirements exceed requirements of UL 1008, switch shall meet the stricter requirements.
- B. Comply with requirements for commissioning specified in Division 01.

- C. Manufacturer's representative shall be factory-authorized and -trained in the installation, testing, and operation of the specified equipment.

1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01 for Commissioning Requirements.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Automatic Switch Co. (ASCO) units are the basis for design of the Project. The following listed manufacturers also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article "Product Options" in Section 260101, and submit shop drawings as specified in the article "Submittals" above.

1. Automatic Switch Co. (ASCO)
2. Cummins Power Generation (Onan)
3. Kohler Power Systems
4. Russelectric, Inc.
5. Zenith Controls, Inc.

2.31 AUTOMATIC TRANSFER SWITCH

- A. Compatible with local power supply, which is 480/277 volts, 3-phase, 4-pole; Level 1 equipment according to NFPA 110; rated in accordance with UL 1008 for continuous loading and total system transfer and shall be suitable for motor, resistance heating, electric-discharge lighting, and tungsten filament lamp loads.
- B. Switching arrangement: Double-throw design, mechanically interlocked to prevent simultaneous connection of both power sources. The contact driving system shall be mechanically held and electrically operated.
 1. Contacts: Silver alloy, capable of making or breaking any load within the rating of the switch.
 - a. Contacts that close to start the engine generator: Include a time delay of transfer switch and engine starting signals, factory set at 10.0 seconds (adjustable from 0-5 minutes).
- C. Controls: Solid-state.
- D. Provide close differential voltage sensing of all phases of both the normal and alternate sources of power.
 1. Settings: Factory preset for:
 - a. Dropout at 87 percent of nominal voltage (adjustable 75-98 percent)
 - b. Pickup at 95 percent of nominal voltage (adjustable 85-100 percent).

- E. The transfer of the load shall occur only if the alternate source has attained factory setting of 95 percent of nominal voltage (adjustable 85-100 percent) and 95 percent of nominal frequency (adjustable 90-100 percent) and the transfer to alternate time delay has expired. The time delay shall be factory set for 0 seconds. (Field adjustable range of 0 to 2 minutes.)
 - 1. Upon return of the normal source to within the limits of the voltage sensor, the switch shall retransfer to the normal source after a retransfer to normal time delay. The time delay shall be factory preset for 15 minutes. (Field-adjustable range of 0.5 to 30 minutes.)
- F. Time delay for engine generator cooldown: Unloaded, running, factory-set at 5 minutes (adjustable 0-5 minutes).
- G. Pilot lights: Green, indicating that the normal source is connected to the load, and red, indicating that the alternate source is connected to the load.
- H. Test switch: Simulates a normal source outage.
- I. Reset switch: To manually retransfer the automatic transfer switch to the normal source, except that retransfer shall occur automatically if alternate source fails.
- J. In-phase monitor control for transfer and retransfer of motor loads.
- K. Enclosure: NEMA 250, Type 1; NEMA ICS 6; and UL 508.
- L. Terminal block: Termination of all auxiliary contacts, switches, pilot lights, and appurtenances mounted in transfer switch enclosure.
- M. Clearly label and identify each indicating light and switch as to its purpose or function.
- N. Automatic solid-state exerciser without load for 0.5 hour weekly.
- O. Relay protection:
 - 1. Full-phase voltage on normal side.
 - 2. Three-phase voltage frequency on generator side.
- P. 4-pole switched neutral for ground fault sensing coordination.

2.90 SOURCE QUALITY CONTROL

- A. Factory-test components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test in accordance with NEMA ICS 1.

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Install each unit level and plumb, securely attached to wall.
- B. Connect wiring as indicated on the drawings and in accordance with manufacturer's recommendations.
- C. Identify components.

3.60 FIELD QUALITY CONTROL

- A. Test transfer switches and components by operating them in all modes. Perform tests recommended by manufacturer under supervision of manufacturer's factory-authorized representative.
- B. Correct deficiencies and report results in writing. Record adjustable relay settings.
- C. Coordinate tests with tests of generator plant and run them concurrently.

3.75 ADJUSTING AND CLEANING

- A. Inspect and clean surfaces and repair damaged finishes to match original finish.
- B. Clean interior of equipment according to manufacturer's instructions.

3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 260500, provide operating instructions.
- B. Coordinate this training with that for generator equipment.

END OF SECTION 263600

SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. A complete lightning protection system for buildings as indicated on the drawings.

1.14 RELATED SECTIONS

- A. Conduit: Section 260533.
- B. Grounding: Section 260526.

1.20 REFERENCES

- A. NFPA 780: Installation of Lightning Protection Systems.
- B. UL 96: Lightning Protection Components.
- C. UL 96A: Installation Requirements for Lightning Protection Systems.

1.21 DEFINITIONS

- A. LPI: Lightning Protection Institute.
- B. NRTL: National recognized testing laboratory.

1.30 SUBMITTALS

- A. Comply with Division 01 and Section 260101.
- B. Shop drawings: For air terminals and mounting accessories.
 - 1. Detail lightning protection system, including air-terminal locations, conductor routes and connections, and bonding and grounding provisions.
 - 2. Indicate use of raceway, and provide data on how concealment requirements will be met.
 - 3. Provide scaled drawings of proposed layout.
- C. Product data: For each type of product specified, including roof adhesive, if used, submit evidence to establish that materials are manufactured, furnished, and recommended for their intended use by a lightning protection manufacturer who is a Manufacturer Member of the Lightning Protection Institute.
- D. Qualification data: For firms and persons specified in "Quality Assurance" Article. Include data on listing or certification by an NRTL or LPI.
- E. Certifications:
 - 1. Certifications required by "Field Quality Control" in Part 3 below.
- F. Reports: Tests and inspections required by "Field Quality Control" in Part 3 below.
- G. Project records:

1. Drawing: As required by Division 01 and Section 260101, at the same scale as contract documents, showing the locations of air terminals, cable routes, connections and grounding, and other components installed; to be made part of Operation and Maintenance manuals.
2. Forms and final documentation as required in "Field Quality Control" in Part 3 below.

1.40 QUALITY ASSURANCE

- A. Install system under the supervision of the manufacturer's authorized and approved representative qualified as follows:
 1. Actively engaged in the installation of lightning protection systems.
 2. Having a satisfactory record of performance, including providing adequate service, as demonstrated by at least 5 systems of the same type, and similar size and duty, which have performed for not less than 2 years.
 3. Certified Member in good standing of the Lightning Protection Institute.
- B. Electrical components, devices, and accessories: Comply with applicable requirements of NFPA 70.
- C. Comply with UL 96 and UL 96A.

1.71 COORDINATION

- A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.
- B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.
- C. Coordinate installation of counterpoise conductor and ground rods with installation of other buried systems and components.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Manufacturers/Installers: Subject to compliance with requirements, provide products by one of the following:
 1. Advanced Lightning Systems, Inc.
 2. Bonded Lightning Protection Systems, Inc.
 3. Brazill Brothers & Associates, Inc.
 4. Dillon Lightning Protection Systems, Inc.
 5. East Coast Lightning Equipment, Inc.
 6. Heary Bros. Lightning Protection Co. Inc.
 7. Thompson Lightning Protection, Inc.

2.20 LIGHTNING PROTECTION SYSTEM COMPONENTS

- A. Comply with UL 96.
- B. Air terminals and conductors: NFPA 780 Class I solid copper unless otherwise indicated.

1. Air terminals: Blunt end. Air terminals shall be approved by Architect prior to installation.
 2. Stack-mounting air terminals: Solid copper.
 3. Air terminals installed on single-ply roof membrane: Designed for this application.
- C. Ground rods, ground loop conductors, and concrete-encased electrodes: Comply with Section 260526 and with standards referenced in this section.
- D. Conduit: Schedule 40 PVC, minimum trade size 1 inch (27 mm).

PART 3 - EXECUTION

3.20 INSTALLATION

- A. Do not begin work until shop drawings have been approved. Notify Architect 24 hours in advance of concealing lightning protection work.
- B. Install lightning protection components and systems according to UL 96A.
- C. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops; make no bends sharper than 90 degrees and minimum bending radius of 8 inches.
- D. Conceal the following conductors unless otherwise indicated on drawings.
 1. System conductors.
 2. Down conductors.
 3. Conductors inside building.
 4. Conductors in normal view from exterior locations at grade within 200 ft (60 m) of building.
- E. Cable connections: Use approved exothermic-welded connections for all connections between conductors and ground rods.
- F. Air terminals shall extend not less than 10 inches (255 mm) above the objects they are to protect.
- G. Counterpoise conductors shall be buried a minimum of twenty four-inches below finished grade.

3.21 CORROSION PROTECTION

- A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.
- B. Install conductors in conduit within wall cavities and where conditions would cause deterioration or corrosion of conductors.

3.22 GROUNDING AND BONDING

- A. Provide equipment grounding and bonding connections sufficiently tight to ensure permanent and effective grounds and bonds.

3.60 FIELD QUALITY CONTROL

- A. On completion of the installation, perform ground resistance test and submit a copy of the results. Ground resistance shall not exceed 10 ohms. Test, correct, and retest until results are satisfactory.
- B. Provide an inspection by an inspector certified by LPI.
 - 1. Inspection shall be performed in accordance with LPI-177, "Inspection Guide for LPI Certified Systems." Submit one copy of LPI-177 and retain one copy at the site during construction.
 - 2. Inspections shall be documented on LPI forms C1-02 and 1-R88. Submit one copy of each completed form.
- C. Provide UL inspection and submit Master Label C.

END OF SECTION 264113

SECTION 264313 - SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Surge protective devices (SPD) for the protection of ac electrical circuits from the effects of lightning-induced currents, substation switching transients, and internally generated transients resulting from inductive or capacitive load switching.

1.14 RELATED SECTIONS

- A. Switchboards: Section 262413.
- B. Circuit breaker: Section 262416, Panelboards.

1.21 DEFINITIONS

- A. SPD: Surge protective device.
- B. LED: Light-emitting diode.
- C. MCOV: Maximum continuous operating voltage.
- D. MOV: Metal-oxide varistor.
- E. VPR: Voltage protection rating.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. Product data: Provide manufacturer's catalog information, including unit dimensions and rated capacities for each type of unit included in the project.
- C. Certifications:
 - 1. Cover page of manufacturer's UL test report for each type of unit, showing that the unit is UL 1449 Third Edition listed.
 - 2. Provide UL 1449 Third Edition listing documentation verifying the following:
 - a. Voltage protection rating (VPR)
 - b. Maximum continuous operating voltage (MCOV)
 - 3. Electromagnetic interference certification in accordance with UL 1283.

1.40 QUALITY ASSURANCE

- A. Every SPD shall be UL 1449 Third Edition listed and labeled.
- B. UL data and visual inspection takes precedence over manufacturer's published documentation.
- C. A single manufacturer shall provide secondary service SPD at each branch circuit panelboard where indicated.

1.80 WARRANTY

- A. In addition to the general project warranty and correction period, provide manufacturer's special warranties providing unlimited replacements of suppressor modules if they are destroyed by transients. Length of warranties:
1. Service entrance SPD: Ten years.
 2. Secondary service SPD: Ten years.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Service entrance SPD: Basis-of-design product: Subject to compliance with requirements, provide service entrance SPD manufactured by Schneider Electric (Square D), or comparable product by one of the following:
1. Eaton Corporation; Cutler-Hammer Products
 2. General Electric Company
 3. Siemens Industry, Inc.
 4. Schneider Electric; Square D Products (basis-of-design)
- B. Secondary service SPD: Basis-of-design product: Subject to compliance with requirements, provide SPD manufactured by Advanced Protection Technologies, or comparable product by one of the following:
1. Advanced Protection Technologies (basis of design)
 2. Eaton Corp.; Cutler-Hammer Products
 3. General Electric Company
 4. Liebert Corp. Div. of Emerson
 5. Siemens Industry, Inc.
 6. Schneider Electric; Square D Products
 7. Surge Suppression Inc.

2.21 SERVICE ENTRANCE SPD

- A. Provide service entrance SPD factory installed and integral to the switchboard specified in Section 26 24 13, Switchboards.
- B. Suppression components shall be MOV based, serviceable, and replaceable.
- C. SPD shall provide surge current paths for the following modes of protection: L-N, L-G, and N-G.
- D. SPD shall incorporate a UL 1283 listed EMI/RFI filter with minimum attenuation of - 50dB at 100 kHz.
- E. Provide terminals for the necessary power and ground connections. Each terminal shall accommodate wire sizes of No. 10 to No. 1 AWG.
- F. SPD shall meet or exceed the following criteria:
1. Peak (maximum) surge current rating (L-N + N-G): 150 kA per phase (8/20 μ s waveform).
 2. The UL 1449 Third Edition; voltage protection ratings (VPR) shall not exceed the following:

<u>System Voltage</u>	<u>L-N</u>	<u>L-G</u>	<u>N-G</u>
480/277V	1200V	1200V	1200V

3. UL 1449 listed maximum continuous operating voltage (MCOV):

<u>System Voltage</u>	<u>Allowable System Voltage Fluctuation</u>	<u>MCOV</u>
480Y/277V	15 percent	320V

- G. SPD shall be equipped with the following diagnostics:

1. Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
2. Audible alarm with on/off silence function and diagnostic test function.

2.22 SECONDARY SERVICE SPD FOR BRANCH CIRCUIT PANELBOARDS

- A. Provide an externally mounted SPD, equal to Advanced Protection Technologies, XAS Series. SPD integral with panelboard shall not be acceptable.
- B. Suppression components shall be MOV based, serviceable, and replaceable.
- C. SPD shall provide surge current paths for the following modes of protection: L-N, L-G, and N-G.
- D. SPD shall incorporate a UL 1283 listed EMI/RFI filter with minimum attenuation of - 50dB at 100 kHz.
- E. Provide terminals for the necessary power and ground connections. Each terminal shall accommodate wire sizes of No. 10 to No. 1 AWG.
- F. SPD shall meet or exceed the following criteria:
 1. Peak (maximum) surge current rating (L-N + N-G): 100 kA per phase (8/20 μs waveform).
 2. The UL 1449 Third Edition; voltage protection ratings (VPR) shall not exceed the following:

<u>System Voltage</u>	<u>L-N</u>	<u>L-G</u>	<u>N-G</u>
208Y/120V	700V	800V	700V

3. UL 1449 listed maximum continuous operating voltage (MCOV):

<u>System Voltage</u>	<u>Allowable System Voltage Fluctuation</u>	<u>MCOV</u>
208Y/120V	25 percent	150V

- G. SPD shall be equipped with the following diagnostics:

1. Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
2. Audible alarm with on/off silence function and diagnostic test function.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Install per manufacturer's installation instructions and recommendations.
- B. Install units plumb, level and rigid without distortion.

3.21 INSTALLING SERVICE ENTRANCE SURGE PROTECTIVE DEVICES

- A. Install on the load side of the main service disconnect.
- B. Keep conductors between SPD and point of attachment short and straight.
- C. Bond SPD ground to the service entrance ground.

3.22 INSTALLING SURGE PROTECTIVE DEVICES FOR PANELBOARDS

- A. Install SPD external to panelboards where indicated on Drawings.
- B. SPD shall be installed per manufacturer's installation instructions with lead lengths as short (less than 12 inches) and straight as possible. Gently twist conductors together.
 - 1. Rearrange circuit breaker locations in panelboards to ensure short and straightest possible leads to each SPD.

3.23 ADJUSTMENTS AND CLEANING

- A. Remove debris from SPD and wipe dust and dirt from all components.
- B. Repaint marred and scratched surfaces with touch up paint to match original finish.

3.60 FIELD QUALITY CONTROL

- A. Check tightness of accessible mechanical and electrical connections to ensure proper torque is applied per manufacturer's recommendations.
- B. Check installed panelboards for proper grounding, fastening and alignment.
- C. Test and inspections:
 - 1. Perform each visual and mechanical inspection and electrical test in accordance with NETA Acceptance Testing Specifications in section, Surge Arresters, Low-Voltage Surge Protection Devices. Certify compliance with test parameters.
 - 2. After installing SPD devices but before electrical circuitry has been energized, test for compliance with requirements.
 - 3. Complete startup procedures according to manufacturer's written instructions.
- D. SPD device shall be considered defective if it does not pass tests and inspections.

END OF SECTION 264313

SECTION 265100 - INTERIOR LIGHTING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Lighting fixtures, including lamps, drivers, and accessories.
- B. Emergency lighting control transfer relay device.

1.14 RELATED SECTIONS

- A. Sections specifying requirements for LEED rating and commissioning are specified in Division 01.
- B. Dimming control: Sections 260923 and 260936.
- C. Occupancy sensors: Section 260923.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. LEED submittal:
 - 1. Product data:
 - a. Energy and Atmosphere (EA), Prerequisite 2: For minimum energy performance.
 - b. Indoor Environmental Quality (IEQ), Credit 6.1: For controllability of systems - lighting.
 - c. Sustainable Sites (SS), Credit 8: For light pollution reduction.
- C. Product data: For each type of lighting fixture indicated, arranged in order of fixture designation. Include data on features, accessories, and the following:
 - 1. Dimensions of fixtures, photometrics and efficiency, wattage, reflectors, glassware, voltage, suspension, and appurtenances.
 - 2. Certified results of laboratory tests for fixtures and lamps for photometric performance.
 - 3. Emergency lighting unit battery and charger.
 - 4. LED drivers
 - 5. Lumen output, rated color temperature, and manufacturer's LED binning procedures.
 - 6. Types of lamps.
- D. Samples: If contractor has selected fixtures not identical to scheduled fixtures, as permitted in Part 2 below as an option, Architect may require submittal of samples.
 - 1. One complete fixture of each approved type, except as otherwise instructed by the Architect.
 - 2. Install approved samples as work of the project, in locations as directed, as standards for all fixtures of the same type.
 - 3. Ascertain that the fixture will fit in the available space and is coordinated with adjacent and connected products.
- E. Maintenance data: For lighting fixtures to include in maintenance manuals specified in Division 01.

1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 260500, Common Work Results for Electrical.
- B. Comply with requirements for LEED certification and commissioning specified in Division 01.
- C. 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.
- D. Comply with NFPA 70.
- E. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.

1.49 COORDINATION

- A. Fixtures, mounting hardware, and trim: Coordinate layout and installation of lighting fixtures with ceiling system and other construction.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Deliver glassware and lamps in their original cartons, clearly labeled.

1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01 for Commissioning Requirements.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Basis-of-design products: Fixtures indicated in the Fixture Schedule on the drawings are the basis of design of the project.
 - 1. Subject to compliance with requirements, provide the scheduled products. Unnamed products will only be considered and approved according to Bidding and Contracting requirements and Division 01 requirements for substitutions.
- B. Subject to compliance with requirements, provide products by one of the following:
 - 1. Drivers:
 - a. Philips/Advance
 - b. Osram Sylvania
 - c. Universal Lighting Technologies
 - d. Lutron
 - e. EldoLED

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

1. Lamps:
 - a. General Electric
 - b. Osram Sylvania
 - c. Philips
 - d. Venture

2.20 FIXTURES, GENERAL

- A. Fixtures shall comply with UL 1598 and be complete with sockets, casings, fittings, holders, shades, glassware, lamps, and appurtenances, wired and completely assembled.
- B. Metal parts: Free from burrs, sharp corners, and edges.
- C. Sheet metal components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- D. Doors, frames, and other internal access: Smoothly 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.
- E. Metal finishes: Painted after fixture fabrication.
- F. 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 metalized film: 90 percent.
- G. Lenses, diffusers, covers, and globes: 100 percent virgin acrylic plastic or annealed crystal glass, unless otherwise indicated, exactly as scheduled or specified in optical details and lighting characteristics.
 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.

2.21 LED DRIVERS

- A. Driver shall operate from a 120-volt or 277-volt, 60-Hz input power source and be suitable for outputting power to 12-volt or 24-volt LED lamp sources, as required.
- B. Drivers, where specified, shall be capable of being dimmed. Dimmable drivers shall be controlled by a Class 2 low-voltage 0-10VDC controller.
- C. Performance Criteria:
 1. Driver shall have a Class A sound rating.
 2. Driver shall have a power factor (PF) greater than 0.90.

3. Driver shall have Total Harmonic Distortion (THD) of input current equal to or less than 20 percent.

D. Driver shall meet FCC and Title 47 CFR regulations for EMI/RFI.

E. Driver shall comply with ANSI C62.41 Class A requirements for transient protection.

2.23 EXIT SIGNS

A. General requirements: Exit signs shall meet the Energy Star Program requirements to operate on 5 W or less input power per face. Comply with UL 924 and the following:

1. Sign colors and lettering size: Comply with authorities having jurisdiction.

B. Internally lighted signs: As follows:

1. Lamps for ac operation: Light-emitting diodes, 70,000 hours minimum rated lamp life.

2.24 EMERGENCY LIGHTING UNITS

A. General requirements: Self-contained units. Comply with UL 924. Units include the following features:

1. Battery: Sealed, maintenance-free, lead-acid type with minimum 10-year nominal life and special warranty.
2. Charger: Fully automatic, solid-state type with sealed transfer relay.
3. Operation: Relay automatically turns lamp on when supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps, and battery is automatically recharged and floated on charger.
4. Wire guard: Where indicated, heavy-chrome-plated wire guard arranged to protect lamp heads or fixtures.
5. Integral time-delay relay: Arranged to hold unit on for fixed interval after restoring power after an outage. Provides adequate time delay to permit high-intensity-discharge lamps to restrike and develop adequate output.

2.65 LAMPS

A. Lamps, LED:

1. The LED manufacturer shall provide the quantity and wattage of LEDs required to achieve the defined lighting output set forth by the lighting fixture manufacturer.
2. LED lamps shall be integrated into an engineered package for the specific lighting fixture application, including heat dissipation components.
3. Color temperature: As specified in lighting fixture schedule, with a tolerance of plus or minus 100K and within a range of three macadam ellipses. Noticeable color temperature variation between adjacent lighting fixtures shall be considered a failure to meet these specifications and shall be replaced at no cost to the owner.
4. Minimum performance characteristics:
 - a. Life: Minimum lumen maintenance of L70 at 50,000 hours, as defined by IES LM-80.
 - b. Lumen Output: Based on absolute photometry, lumens (total luminous flux exiting the physical luminaire), as specified on contract drawings and schedules.
 - c. Color Rendering Index: Rated at 85 or higher.

2.72 FIXTURE SUPPORT COMPONENTS

- A. Comply with Section 260500, Common Work Results for Electrical, for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-stem hangers: 1/2-inch (12-mm) steel tubing with swivel ball fitting and ceiling canopy. Finish same as fixture.
- C. Twin-stem hangers: Two, 1/2-inch (12-mm) steel tubes with single canopy arranged to mount a single fixture. Finish same as fixture.
- D. Rod hangers: 3/16-inch- (5-mm-) minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.
- F. Aircraft cable support: Use cable, anchorages, and intermediate supports recommended by fixture manufacturer.

2.82 FINISHES

- A. Fixtures: Manufacturer's standard, unless otherwise indicated.
 - 1. Paint finish: Applied after fabrication over corrosion-resistant treatment or primer, free of defects.
 - 2. Metallic finish: Corrosion-resistant.

PART 3 - EXECUTION

3.05 PREPARATION

- A. Before ordering the light fixtures, consult with the installer of the ceilings to ensure that the correct fixture trim is supplied and installed. Provide the supports and accessories required for installation in each ceiling system.
- B. Before ordering the light fixtures, verify the specified voltage with the voltage shown on the drawings to ensure the correct voltage is supplied.

3.20 INSTALLATION

- A. Furnish and install a complete lighting fixture for every outlet indicated on the drawings so that every outlet shall be properly provided with a suitable fixture of type specified, of wattage indicated.
- B. Fixture wire shall bear UL label. Fixture wiring for fixtures and branch circuit wiring in fixture channels shall be type THHN.
- C. Each fixture shall be completely equipped with lamps of the size, type, wattage and shape indicated and specified. Lamps shall be of the proper voltage for the building.
- D. Furnish fixtures in the quantities, sizes, and types indicated on drawings.

- E. Where a letter designating fixture type is adjacent to a row of fixtures, it shall be understood that all fixtures in the row shall be of this type, consisting of either four-foot or eight-foot units, the rows consisting of the total lengths indicated. Where the catalog numbers of the fixtures refer to 4-foot units, 8-foot units may be used where applicable.
- F. Provide recessed fixtures with flexible conduit connector and wire (fixture whip), or a removable wiring access plate, so that they may be wired without removing ballast cover. Plate shall be screwed to fixture housing and conduit shall be securely attached and grounded to fixture to meet NEC requirements.

3.21 FIXTURE SUPPORT

- A. Support from building structure: Provide fasteners appropriate to the supporting substrate, and wire, jack chain, or rods as specified for particular fixture types below.
 - 1. Provide channels bolted or welded between joists where required to obtain proper spacing for lighting supports.
 - 2. Connections to joists or beams: Beam clamps. For wire supports, wrap wire securely around structural member.
 - 3. Connections to concrete: Embedded, as specified in Section 260533, Conduits.
- B. In suspended plaster and drywall ceilings, fixtures may be supported from the suspended ceiling construction. Fasten box and fixture supports securely to suspension system. Where fixtures are surface-mounted, cut neat holes in the plaster as required for supports.
- C. Recessed fixtures in suspended acoustical ceilings: Coordinate fixture installation with ceiling installer. Ensure that ceiling supports are located to clear fixtures.
 - 1. Support from building structure: Use fasteners specified in Section 260533, Conduits, and 0.25-inch (6-mm) rods, jack chains, or No. 10 wire.
 - a. Provide 4 supports for each individual fixture, one at each corner of fixture. In continuous rows, install additional supports at each joint.
- D. Lighting fixtures mounted in gymnasium with open bar joists: Attach to a structural channel attached to the top of the joists with fixture mounted flush with the bottom of the joists. Provide lenses and ballasts with safety chains.
- E. Surface-mounted and stem-suspended fixtures on or below suspended acoustical ceilings: Supported from the building structure above with 0.25-inch (6-mm) rods.
 - 1. Provide four supports for each individual fixture, 2 at each end of fixture. In continuous rows, install an additional support at each joint.
 - 2. Surface-mounted fixtures mounted on low-density ceilings shall be provided with spacers where required.
- F. Where it is necessary for a fixture to be installed directly below an air duct, install two hanger rods, one on each side of the duct, bolted to a channel or angle suspended from the hangers under the duct, and support the fixtures from the suspended channel or angle.

3.75 CLEANING

- A. Light fixtures, used for temporary lighting during construction, shall be cleaned free of construction dirt to like-new condition, and re-lamped with the specified lamps.

END OF SECTION 265100

SECTION 265600 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Poles
- B. Fixtures

1.14 RELATED SECTIONS

- A. Sections specifying requirements for LEED rating and commissioning are specified in Division 01.
- B. Conduits: Section 260533.
- C. Wires and cables: Section 260519.
- D. Equipment foundations: Section 260528.
- E. Excavation and fill for electrical work: Section 260501.

1.20 DEFINITIONS

- A. Bracket: An attachment to a standard, on which a luminaire is carried.
- B. Luminaire: A lighting device consisting of a light source together with its direct appurtenances, including globe, reflector, refractor, housing, and such support as is integral with the housing. The standard and the bracket are not part of the luminaire.
- C. Pole: A support generally used to carry overhead lighting distribution circuits.
- D. Standard (lamp post): A support used to carry a luminaire, provided with
 - 1. Internal attachments for wiring and
 - 2. External attachments for brackets (if any) and luminaire.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 260101.
- B. LEED submittal:
 - 1. Product data:
 - a. Energy and Atmosphere (EA), Prerequisite 2: For minimum energy performance.
 - b. Indoor Environmental Quality (IEQ), Credit 6.1: For controllability of systems - lighting.
 - c. Sustainable Sites (SS), Credit 8: For light pollution reduction.
- C. Product data: Submit for each type of fixture, pole and standard.
 - 1. Type
 - 2. Wattage
 - 3. Voltage

4. Efficiency
5. Suspension
6. Glassware
7. Finished diameters
8. Mounting heights
9. Lamps
10. LED drivers
11. Length and diameter of poles and standards
12. Appurtenances

- D. Shop drawings shall show complete dimensions of complete assembled unit with accessories. Include wiring diagrams, showing clearly manufacturer-installed and field-installed wiring.
- E. Photometric data: Point-to-point, indicating footcandle readings minimum 10 feet on centers along the horizontal plane, for layout shown on the site plans. Provide complete data to a point where the calculations indicate zero foot candles.
- F. Samples: If contractor has selected fixtures not identical to scheduled fixtures, as permitted in Part 2 below as an option, Architect may require submittal of samples.
1. One complete fixture of each approved type, except as otherwise instructed by the Architect.
 2. Install approved samples as work of the project, in locations as directed, as standards for all fixtures of the same type.
 3. If substitute fixtures should be requested, submit samples as required.
 4. For selection, manufacturer's complete line of colors and textures.

1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 260500, Common Work Results for Electrical.
- B. Comply with requirements for LEED certification and commissioning specified in Division 01.

1.50 DELIVERY, STORAGE, AND HANDLING

- A. Deliver glassware and lamps in their original cartons, clearly labeled.

1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01 for Commissioning Requirements.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Basis-of-design products: Fixtures indicated in the Fixture Schedule on the drawings are the basis of design of the project.

1. Subject to compliance with requirements, provide the scheduled products. Unnamed products will only be considered and approved according to bidding and Contracting requirements and Division 01 requirements for substitutions.
- B. Subject to compliance with requirements, provide products by one of the following:
1. LED drivers:
 - a. EldoLED
 - b. Lutron
 - c. Osram Sylvania
 - d. Philips/Advance
 - e. Universal Lighting Technologies
 2. Lamps:
 - a. General Electric
 - b. Osram Sylvania
 - c. Philips
 - d. Venture
- 2.11 CONCRETE
- A. Concrete shall be 3,000 psi strength.
- 2.21 ELECTRICAL POLES AND STANDARDS
- A. Metal lighting poles and standards: Provide metal, raceway-type, lighting poles and standards, of sizes and types indicated, comprised of shafts and tenon joints. Equip with grounding connections readily accessible from handhole or transformer base access doors; and construct of the following materials and additional construction features:
 1. Material: Spun aluminum.
 2. Configuration: Anchor base type with hand hole and cover where indicated.
 3. Metal lighting standard accessories: Provide accessories including anchor bolts, as recommended by lighting standard manufacturer, of sizes and materials needed to meet erection and loading application requirements.
- 2.23 EXTERIOR LIGHTING FIXTURES
- A. Provide lighting fixtures of sizes, types, and ratings scheduled, complete with, but not limited to, housings, energy-efficient ballasts, starters, and wiring.
- 2.25 LED DRIVERS
- A. Driver shall operate from a 120-volt or 277-volt, 60-Hz input power source and be suitable for outputting power to 12-volt or 24-volt LED lamp sources, as required.
 - B. Drivers, where specified, shall be capable of being dimmed. Dimmable drivers shall be controlled by a Class 2 low-voltage 0-10VDC controller.
 - C. Performance criteria:
 1. Driver shall have a Class A sound rating.

2. Driver shall have a power factor (PF) greater than 0.90.
3. Driver shall have Total Harmonic Distortion (THD) of input current equal to or less than 20 percent.

D. Driver shall meet FCC and Title 47 CFR regulations for EMI/RFI.

E. Driver shall comply with ANSI C62.41 Class A requirements for transient protection.

2.26 LAMPS

A. Lamps, LED:

1. The LED manufacturer shall provide the quantity and wattage of LEDs required to achieve the defined lighting output set forth by the lighting fixture manufacturer.
2. LED lamps shall be integrated into an engineered package for the specific lighting fixture application, including heat dissipation components.
3. Color temperature: As specified in lighting fixture schedule, with a tolerance of plus or minus 100K and within a range of three macadam ellipses. Noticeable color temperature variations between adjacent lighting fixtures shall be considered a failure to meet these specifications and shall be replaced at no cost to the Owner.
4. Minimum performance characteristics:
 - a. Life: Minimum lumen maintenance of L70 at 50,000 hours, as defined by IES LM-80.
 - b. Lumen output: Based on absolute photometry, lumens (total luminous flux exiting the physical luminaire), as specified on contract drawings and schedules.
 - c. Color rendering index: Rated at 85 or higher.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Install poles, accessories, and fixtures as indicated, in accordance with manufacturer's written instructions, applicable requirements of NFPA 70, NESC and NEMA standards, and with recognized industry practices.

3.21 INSTALLING POLES

- A. Provide reinforced concrete bases as shown on the drawings. Chamfer exposed edges of concrete. Grout base plates to concrete bases to provide proper leveling.
- B. Base size and depth shall be as indicated on the drawings.
- C. Use belt slings or rope, not chain or cable, to protect finishes when raising and setting finished poles and standards.
- D. Where poles and standards are indicated to be embedded in soil, set to depth required for adequate structural support, but not less than minimum 5 foot 6 inches below finish grade.
- E. Set poles and standards plumb. Support adequately during backfilling, or when anchoring them to the foundations.
- F. Provide sufficient space encompassing hand-access and cable-entrance holes for installation of underground cabling where indicated.

- G. Fasten electrical lighting fixtures and brackets securely to indicated structural supports, including poles/standards; and ensure that installed fixtures are plumb and level.
- H. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and B, and the National Electrical Code.

3.23 GROUNDING

- A. Provide equipment grounding connections for poles and standards as indicated, and in accordance with Section 260526, Grounding and Bonding. Tighten connections to comply with tightening torques specified in UL 486A.

3.60 FIELD QUALITY CONTROL

- A. At the date of substantial completion, replace lamps in exterior lighting fixtures which are observed to be noticeably dimmed after Contractor's use and testing, as judged by the Architect.

3.70 ADJUSTING AND CLEANING

- A. Aim adjustable lighting fixtures and lamps in night test of system. Verify that measured illuminance values comply with approved photometric diagram.
- B. Clean lighting fixtures of dirt and debris upon completion of installation.
- C. Protect installed fixtures from damage during construction period.

3.80 DEMONSTRATION

- A. Upon completion of installation of exterior lighting fixtures, and associated electrical supply circuitry, apply electrical energy to circuitry to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

END OF SECTION 265600

SECTION 270101 - COMMUNICATIONS GENERAL PROVISIONS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. General provisions and requirements for communications work.

1.14 RELATED SECTIONS

- A. Requirements of this section generally supplement requirements of Division 01.
- B. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.

1.20 REFERENCES

- A. NFPA 10: Portable Fire Extinguishers.
- B. NFPA 241: Safeguarding Construction, Alteration, and Demolition Operations.

1.24 SYSTEM DESCRIPTION

- A. The full set of Contract Documents applies to work of Division 27.
- B. Visit the site and study all aspects of the project and working conditions, as required by General and Supplementary Conditions, Bidding and Contracting Requirements, Drawings, and Specifications. Verify field dimensions.
- C. The work covered in technical sections includes the furnishing of all labor, equipment and materials, and the performance of all operations pertinent to the work described.
- D. Except as required otherwise in Division 01, promptly obtain and pay for, all necessary signatures and paperwork, all permits, fees and inspections required for work of this division by authorities having jurisdiction, including any utility connection or extension charge. No payment will be made until a copy of the permit is forwarded to the Owner.
- E. Communications work of this project includes, as a brief general description, the following:
 - 1. Voice
 - 2. Data
 - 3. Audio/Video
 - 4. The project includes commissioning under the direction of a Commissioning Agent (CxA).
 - 5. The project will be LEED certified.
- F. See Division 01 for requirements related to LEED certification, commissioning, limits on use of site, time restrictions on work, limits on utility outages or shutdowns, and phasing (sequencing) and scheduling.

1.26 PRODUCT OPTIONS

- A. Except as modified by provisions of Bidding and Contracting Requirements and Division 01, these options apply to Division 27 specifications.

- B. General: Where Contractor is permitted to use a product other than the specified item and model named as the basis of design, Contractor is responsible for all coordination and additional costs as specified in article "Substitutions" below for substitutions.
- C. Products specified by reference standards or by description only: Any product meeting those standards or description.
- D. Products specified by naming one or more manufacturers, or model name or catalog reference number: Products specified establish a standard of quality, options to be included, and performance.
 - 1. Where other acceptable manufacturers are named, Contractor may provide products of those named manufacturers only, which meet the specifications.
 - 2. Where specification permits "equal" products, without naming other acceptable manufacturers, Contractor may use products of any manufacturer, which meet the specifications.
- E. Products specified by naming one manufacturer and particular product, with no provision for other options: No options or substitutions allowed.

1.27 SUBSTITUTIONS

- A. Substitutions will be considered only as permitted or required by the Bidding and Contracting Requirements and Division 01. Except as modified by those requirements, the requirements below apply to Division 27 specifications.
- B. Substitutions may be considered when a product becomes unavailable through no fault of the Contractor.
- C. Document each request with complete data substantiating compliance of proposed substitution with contract documents.
- D. A request constitutes a representation that the Bidder or Contractor:
 - 1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product.
 - 2. Will provide the same warranty for the substitution as for the specified product.
 - 3. Will coordinate installation and make changes to other work which may be required for the work to be complete with no additional cost to Owner.
 - 4. Waives claims for additional costs or time extension which may subsequently become apparent.
 - 5. Will reimburse Owner for review or redesign services associated with re-approval by authorities.
- E. Substitutions will not be considered when they are indicated or implied on shop drawing or product data submittals, without separate written request, or when acceptance will require revision to the Contract Documents.
- F. Substitution submittal procedure is specified in Bidding and Contracting Requirements and Division 01.

1.28 MATERIALS AND EQUIPMENT

- A. All materials and equipment shall be new and the best of their respective kinds, suitable for the conditions and duties imposed on them by the project and of representative manufacturer. The description, characteristics and requirements of the materials to be used shall be in accordance with the specifications.
- B. All equipment, construction and installation must meet requirements of local, state and federal governing codes.
- C. Singular number: In cases where material, a device, or part of the equipment is referred to in the singular number in the specifications, it is intended that such reference shall apply to as many items of material, devices, or parts of the equipment as are required to complete the installation as shown on the drawings or required for proper operation of the system.
- D. Terms have the following meanings:
 - 1. Furnish: Supply item
 - 2. Install: Mount and connect item
 - 3. Provide: Furnish and install
- E. All materials and equipment shall be installed and completed in a first class and workmanlike manner and in accordance with the best modern methods, practice and manufacturers' instructions. Any work which shall not present an orderly and neat or workmanlike appearance shall be removed and replaced with satisfactory work when so directed in writing by the Architect.
- F. The specifications and drawings are intended to define the minimum requirements, as to quality of materials, construction, finish and overall workmanship.
- G. General Conditions describe the correlation and intent of the Contract Documents. In case of discrepancies between the specifications and drawings, the specifications should be followed as to the general methods and principles and the drawings followed as to sizes, capacities and specifics for corresponding parts. If sizes are omitted, the Architect will determine sizes to be utilized.
- H. In all cases of doubt, uncertainty, or conflict as to the true meaning of the specifications or drawings, it is the responsibility of the Contractor to notify the Architect of said uncertainty, doubt, or conflict and obtain a decision as to the intent prior to initiating any work which may be affected by this decision.

1.29 COORDINATION

- A. Should a situation develop during construction to prevent the proper installation of any equipment or item where shown on the drawings, call the situation to the attention of the Architect and await a written decision.
- B. Plan and coordinate all work to proceed in an orderly and continuous manner without undue delay, and in conformance with the project schedule. Submit samples, shop drawings, schedules, insurance policies and certificates, and the like in time to avoid delays in actual construction. Coordinate communications work so that work of each trade is completed before other construction begins which would obstruct it.
- C. Coordinate trades to ensure that proper clearances between work of the various trades allow access to items which require operation and maintenance.

- D. Coordinate location and elevation of all conduit, light fixtures, equipment, and appurtenances in such a manner that the finished installation is as indicated on drawings. In the event difficulties are encountered which prevent this, it is the Contractor's responsibility to bring this to the attention of the Architect prior to initiation of work. Correct improperly coordinated installation at no additional cost.
- E. The Contractors' assistants shall include a competent communications foreman, who shall be on the premises at all times to check, layout, coordinate and superintend the installation of work. The foreman shall establish all basic requirements relative to the work before starting, and be responsible for the accuracy thereof.

1.30 SUBMITTALS

A. Manufacturers' and subcontractors' lists:

- 1. As specified in Division 01, submit a complete list of proposed manufacturers for all equipment, materials and subcontractors used for the work of this division. Lists shall follow the sequence of the specifications. No considerations will be given for partial or incomplete lists. After review of lists, submit shop drawings and product data.

B. Shop drawings and product data:

- 1. Submit in accordance with the requirements of Division 01 or as established at the preconstruction conference, the required number of copies of Shop Drawings and Product Data for every item of equipment. Shop drawings or product data will not be considered until Manufacturers' Lists have been approved. Shop drawings and product data shall be submitted, as required by the General Conditions, with sufficient time for checking, return to Contractor, and resubmission as required before Contractor shall install any item.
- 2. Each item submitted shall be properly labeled, indicating the specific service for which the equipment or material is to be used, section and paragraph number of specification or drawing number to which it applies, Contractor's name and project name and number. Data submitted shall be specific and shall include product data and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents. Clearly identify each item within the data. Data of a general nature will not be accepted. Each sheet must clearly show the project name and number.
- 3. The review of a shop drawing or product data shall not be considered as a guarantee of the measurements or building conditions or that the shop drawings or product data have been checked to see that item submitted properly fits the building conditions. This review shall not relieve the Contractor of the responsibility for furnishing material or performing work as required by the contract documents, for correctness of dimensions and quantities, or for proper coordination of details and interfaces among trades.
- 4. All exclusively communications items furnished as items associated with mechanical items but not specifically described in the mechanical item submission, shall be submitted as a separate submittal but shall be clearly marked as associated with the mechanical item by identified specification paragraph.
- 5. Product data sheets shall be 8.5-inches by 11-inches cut sheets for operating and maintenance manual.

C. Submit at least three copies of the results of every test required under any section in this division.

- D. Specialist shall submit a list of at least three projects similar to this project in type, size, and quality, which have been in place and operating satisfactorily for at least five years.

1. Include project name, address, name and phone number of owner's representative, and project type and size.

E. After the work is completed, submit all required certificates of approval from approved inspection agencies and authorities having jurisdiction over work of this division. Certificates of approval must be received by the Architect prior to final acceptance of the work.

1.34 SPECIALIST

A. The term "Specialist" as used in the specification shall mean an individual or firm of established reputation (or, if newly organized, whose personnel have previously established a reputation in the same field,) which is regularly engaged in, and which maintains a regular force of workers skilled in either (as applicable) manufacturing or fabricating items required by the contract, installing items required by the contract, or otherwise performing work required by the contract. Where the specification requires installation by a specialist, the term shall also be deemed to mean the manufacturer of the item, an individual or firm licensed by the manufacturer, or an individual or firm who will perform the work under the manufacturer's direct supervision.

1.35 CONTRACT CLOSEOUT SUBMITTALS

A. Project record documents:

1. Maintain on site one set of the following record documents; record actual revisions to the work of this division:

- a. Contract Drawings.
- b. Specifications.
- c. Addenda.
- d. Change Orders and other Modifications to the Contract.
- e. Reviewed shop drawings, product data, and samples.

2. Maintain record documents separate from documents used for construction.

3. Record information concurrent with construction progress.

4. Specifications: Legibly mark and record in each section a description of actual products installed, including the following:

- a. Manufacturer's name and product model and number.
- b. Product options, substitutions, or alternates utilized.
- c. Changes made by addenda and modifications.

5. Record documents and shop drawings: Legibly mark each item to record actual construction, including:

- a. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
- b. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the work.
- c. Field changes of dimension and detail.
- d. Details not on original Contract Drawings.

6. Submit documents as specified in Division 01.

B. Operation and maintenance data:

1. Submit sets prior to final inspection as specified in Division 01. Unless otherwise specified in Division 01, submit no fewer than three sets. In addition to requirements specified in Division 01, submit operating and maintenance manuals for the work of this division as specified below.
2. Binders: Provide large enough binders, and sufficient quantity, that the required contents can be easily turned, removed, and reinserted.
 - a. Self-expanding fast lock type.
 - b. Three telescoping metal posts.
 - c. Durable plastic covers.
 - d. Angle spline with guide flanges.
 - e. Text page size - 8.5 by 11 inches.
 - f. Boorum and Pease, Stock No. C-619-3 expansion 3 inch to 5 inch or Stock No. C-1219 expansion 1.5 inch to 2.5 inch, or equal by National or Wilson Jones.
3. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS," and title of project. Print on spine of binder "O & M INSTRUCTIONS." If more than one binder is required, print covers and spines with volume numbers. Include in the front of every binder an index to all binders.
4. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.
5. Contents: Prepare a Table of Contents for each volume, with each product or system description identified, typed on white paper.
6. Part 1: Directory, listing names, addresses, and telephone numbers of communications engineers; contractor; communications subcontractors; and major communications equipment suppliers.
7. Part 2: Operation and maintenance instructions, arranged by specification section. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers. Identify the following:
 - a. Significant design criteria.
 - b. List of equipment.
 - c. Parts list for each component, including recommended spare parts list.
 - d. Operating instructions.
 - e. Maintenance instructions for equipment and systems.
 - f. Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.
8. Part 3: Project documents and certificates, including the following:
 - a. Shop drawings and product data.
 - b. Photocopies of certificates.
 - c. Photocopies of warranties, guarantees, and bonds.
 - d. Test reports: Copies of the results of all tests required under all sections of specifications.
9. Submit one copy of completed volumes in final form 15 days prior to final inspection. This copy will be returned after final inspection, with Engineer comments. Revise content of documents as required prior to final submittal.
10. Submit final volumes revised, within ten days after final inspection.
11. Submit DVD optical disc storage media specified in Section 270500.

1.42 REGULATORY REQUIREMENTS

- A. When these specifications call for materials or construction of a better quality or larger sizes than required by the following codes and standards, the provisions of the specifications shall take precedence.
- B. Provide, without extra charge, any additional materials and labor which may be required for compliance with these codes and standards even though the work is not mentioned in these specifications or shown on the contract drawings.
- C. Perform the work of this division in strict accordance with the following authorities. The latest revision of these codes accepted by the authority having jurisdiction as of the date of the contract documents shall apply.
 - 1. The communications, building, fire, and safety codes of the state and county or city in which the work is being performed.
 - 2. The National Electric Code, NFPA 70 (NEC).
 - 3. The National Fire Protection Association Code. (NFPA)
 - 4. International Building Code (IBC).
 - 5. International Energy Conservation, Fire, and Communications Codes (ICC).

1.43 REFERENCE STANDARDS

- A. Perform the work of this division using the standards of the following organizations, as referred to in technical sections, as a minimum requirement for construction and testing. Unless specified otherwise in Bidding and Contract Documents or Division 01, the latest revision current as of the date of the contract documents shall apply.
 - 1. Factory Mutual (FM)
 - 2. Federal Specifications (FS)
 - 3. Military Standards (Mil. Std.)
 - 4. American National Standards Institute (ANSI)
 - 5. American Society for Testing and Materials (ASTM)
 - 6. International Code Council (ICC)
 - 7. Institute of Communications and Electronics Engineers (IEEE)
 - 8. National Communications Code (NEC) (NFPA 70)
 - 9. National Communications Manufacturer's Association (NEMA)
 - 10. National Fire Protection Association (NFPA)
 - 11. The Occupational Safety and Health Act (OSHA)
 - 12. Underwriters Laboratory Inc. (UL)
 - 13. American Association of State Highway and Transportation Officials (AASHTO)
 - 14. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)
 - 15. Maryland Occupational Safety and Health Act (MOSHA)
 - 16. Illuminating Engineering Society of North America (IESNA)

1.53 TEMPORARY STORAGE

- A. Maintain upon premises, where directed, a storage area, and be responsible for all contents within these areas. Provide all security measures necessary for this area.
- B. Area shall be maintained and shall be returned to original condition at the completion of the project.
- C. Store communications construction materials such as wire, raceways and boxes, devices, and equipment in buildings, enclosed trailers, or portable enclosed warehouses.

1. Materials and products subject to damage from moisture: Store in dry locations. If necessary, protect with protective wraps or covers.
 2. Plastics and other materials and products subject to damage from heat or cold: Store at manufacturer's recommended temperatures.
 3. Plastics and other materials and products subject to damage from sunlight: Protect from sunlight.
- D. Communications equipment such as motor controllers, panelboards and circuit breakers stored before installation and installed during construction: Provide clean, dry locations at manufacturer's recommended temperatures, and cover or wrap if required to protect from incidental damage.

1.54 PROTECTION

- A. Each trade and subcontractor is responsible for preventing damage and soiling of work performed by other trades or subcontractors. Each trade and subcontractor is responsible for providing temporary protection of its own work.
1. Protect work from spills, splatters, drippings, adhesives, bitumens, mortars, paints, plasters, and damage from welding or burning.
 2. Protect finished work from damage, defacement, staining, or scratching.
 3. Protect finishes from cleaning agents, or grinding and finishing equipment.
 4. Protect adjacent and finished work from damage, using tape, masking, covers or coatings and protective enclosures.
 5. Coordinate installations and temporarily remove items to avoid damage from finishing work.
- B. Repair all damage or soiling to the complete satisfaction of the Architect; replace any materials or work damaged to such an extent that they cannot be restored to their original condition, all at no addition to the Contract sum.
- C. Protect work stored in place and supplies stored in the building.
1. Store materials and products, subject to damage from moisture, in dry locations. If necessary, protect in wraps or covers.
 2. Store plastics, other materials, and products subject to damage from heat or cold at manufacturer's recommended temperatures.
- D. Protect communications materials and products from weather events and accidents of construction.
- E. Use of sidewalk or roadway areas outside of the property lines shall be with permission and approval of the local authorities having jurisdiction.

1.55 FIRE PROTECTION

- A. As a minimum, provide hand-carried, portable, UL-rated extinguishers with each work crew working inside the building.
- B. Select extinguishers in accordance with NFPA 10 and NFPA 241 for classification, extinguishing agent, and size required by location and class of fire exposure.

1.60 PROJECT CONDITIONS

- A. Drawings showing utilities in concealed locations are based on the best information available but are not represented as being precisely correct. Work of the contract includes digging, cutting,

drilling, using nondestructive methods, and other methods of locating concealed utilities in the field, as well as patching and repairing as specified in "Cutting and Patching" below.

- B. If, in the course of the work, workers encounter a material they suspect to present some hazard:
 - 1. Promptly notify the Architect in writing.
 - 2. Do not perform any work which would disturb the suspected material until written instructions have been received.

1.80 WARRANTY

- A. All work and equipment provided as work of this division shall be fully warranted under the general project warranty. In addition, provide added special warranties as specified in individual sections.
- B. During the correction period, the Contractor shall promptly correct any work found to be defective or otherwise not in accordance with the requirements of the Contract Documents, on receipt of written notice from the Owner. Except as otherwise required in General Conditions and Division 01, the correction period is two years after the date of substantial completion of the work. Work requiring correction shall promptly be repaired or completely replaced at no addition to the Contract Sum.
- C. When use of the permanent equipment has been permitted for temporary services during construction of the building, the warranty and correction periods shall nevertheless begin at the time of substantial completion, unless another date of acceptance has been agreed to by the Owner.
- D. Special warranties are warranties required by individual specification sections, incidental product warranties, manufacturers' standard warranties, installer or subcontractor service agreements, and other individual warranties in addition to the general project warranty.
- E. Provide copies of warranties as required for Operation and Maintenance Manual specified above, and by Division 01.
- F. For items of work delayed beyond date of substantial completion, provide updated submittal within ten days after acceptance, listing date of acceptance as start of warranty period.

1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.11 CUTTING AND PATCHING

- A. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
- B. Cut walls, floors, partitions, roofs, and other appurtenances for the passage or accommodation of conduits. Close superfluous openings and remove all debris caused by work of this division.
- C. No cutting of any structure or finish shall be done until the condition requiring such cutting has been examined and approved by the Architect.
- D. New or existing surfaces disturbed as a result of such cutting or otherwise damaged shall be restored to match original work and all materials used for any patching or mending shall conform to the class of materials originally installed.
- E. Refinish surfaces to match adjacent finish. For continuous surfaces, refinish to nearest intersection or natural break. For an assembly, refinish entire unit.

3.14 TEMPORARY FACILITIES

- A. Temporary water facilities, electricity, telephone, toilet facilities, and temporary heat, shall be provided as specified in Division 01.

3.40 PROGRESS MEETINGS

- A. Progress meetings shall be held as specified in Division 01, and also when and if the Contractor or Architect finds them necessary or advantageous to progress of work.
- B. Contractor, those subcontractors and those material suppliers concerned with current progress or with the scheduling of future progress, Architect and Owner shall each be represented at these meetings by persons familiar with the details of work and authorized to conclude matters relating to work progress.

3.82 COMMISSIONING

- A. Comply with requirements of 'Commissioning' in Part 1 above.

END OF SECTION 270101

SECTION 270500 - COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Requirements applicable to work of more than one section of Division 27.
- B. Communications identification.
- C. Testing wiring systems.

1.14 RELATED SECTIONS

- A. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.
- B. Operation and Maintenance Manuals: Division 01 and Section 270101.
- C. Painting: Division 09.

1.21 DEFINITIONS

- A. Project correction period: A period after Substantial Completion of the work during which the Contractor shall correct every part of the work found to be not in accordance with the requirements of the contract documents, promptly after receipt of written notice.
- B. Qualified testing agency: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ASTM E 548; and with additional qualifications specified in individual sections; and where required by authorities having jurisdiction, that is acceptable to authorities.
 - 1. NRTL: A national recognized testing laboratory according to 29 CFR 1910.7.
 - 2. NVLAP: A testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program.

1.26 DESIGN REQUIREMENTS

- A. The drawings and system performances have been designed on the basis of using the particular manufacturers' products specified and scheduled on the drawings.
- B. Products of other manufacturers that are listed under the article "Acceptable Manufacturers," or permitted as "equal," are permitted provided:
 - 1. Product shall meet the specifications.
 - 2. Contractor shall make, without addition to the contract sum, all adjustments for deviations so that the final installation is complete and functions as the design basis product is intended.
- C. Do not propose products with dimensions or other characteristics different from the design basis product that make their use impractical or cause functional fit, access, or connection problems.
- D. The contract drawings are generally diagrammatic, and do not indicate all fittings or offsets in conduit or all pull boxes, access panels, or other specialties required.

1. Install conduit exposed to view parallel with the lines of the building and as close to walls, columns, and ceilings as may be practical, maintaining adequate clearance for access at parts requiring servicing.
2. Install conduit a sufficient distance from other work to permit a clearance of not less than 0.5 inch (15 mm) between its finished covering and adjacent work.
3. No conduit shall be run below the head of a window or door.
4. Pull boxes and other appurtenances which require operation or maintenance shall be easily accessible. Do not cut or form handholes for operation or maintenance of appliances through walls or ceilings.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 270101.
- B. Test reports: Show that tests specified in Part 3 below demonstrate the specified results.
- C. LEED submittal:
 1. Product data for Indoor Environmental Quality (IEQ) Credit 4.1: For adhesives and sealants, include printed statement of VOC content.
 2. Product data for Indoor Environmental Quality (IEQ) Credit 4.4: For wood products such as plywood equipment backboards, include printed statement of non-urea-formaldehyde component present in material.

1.40 QUALITY ASSURANCE

- A. Provide materials and perform work in accordance with the electrical, building, fire, and safety codes and regulations of the state, county, or city in which the work is performed.
- B. Communications equipment, materials and devices provided or installed as work of Division 27 shall bear UL label, or, if UL label is not available, the item shall be tested and labeled by a qualified testing agency, acceptable to authorities having jurisdiction, and in accordance with NFPA 70. Provide testing, if required, without addition to the contract sum.
- C. Qualifications of DVD documentation technician: For video documentation specified in "Operating Instructions (Demonstration)," employ persons knowledgeable in DVD optical storage media for video and audio production and editing.
- D. The project shall be LEED certified. See requirements specified in Division 01 and individual sections for LEED requirements, waste and air quality control.
- E. VOC content: Field-applied adhesives and sealants, limits per South Coast Air Quality Management District (SCAQMD), Rule No. 1168.
- F. Products shall contain no urea-formaldehyde content.

1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractors' and subcontractors' responsibilities are described in Division 01.

PART 2 - PRODUCTS

2.10 MATERIALS

- A. Telephone, data, and communications equipment backing panels: Plywood, DOC PS 1, Exposure 1, C-D Plugged, fire-retardant treated in accordance with AWPA C27, in thickness indicated, not less than 0.5 inch (13 mm) nominal.
 - 1. One side finished.
- B. Wood-preserved-treated lumber: Treated by pressure process, AWPA C2, with chemicals acceptable to authorities having jurisdiction, and marked with treatment quality mark of an inspection agency approved by the ALSC Board of Review.
 - 1. Application: Treat items indicated on the drawings, and the following:
 - a. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, or waterproofing.
 - b. Wood sills, sleepers, blocking, and similar concealed members in contact with masonry or concrete.
 - c. Wood framing and furring attached directly to the interior of below-grade exterior masonry or concrete walls.
 - d. Wood framing members that are less than 18 inches (460 mm) above the ground in crawlspaces or unexcavated areas.
 - e. Wood floor plates that are installed over concrete slabs-on-grade.
- C. Nameplates: Laminated plastic, engraved, white letters on black background, except where other colors are noted or specified.
 - 1. Size: Minimum 0.75 inch (19 mm) by 2.5 inches (64 mm).
 - 2. Letter size: Minimum height 0.1875 inch (5 mm).
 - 3. Fasteners: Vandalproof brass screws or rivets.
- D. Aircraft cable: 0.25-inch (6-mm) steel wire rope, galvanized, construction 7 by 19 strands, minimum 7000 lbs (31138 N) breaking strength.

2.21 DATE-SENSITIVE EQUIPMENT

- A. Date-sensitive equipment: Systems, equipment, or components which use or process date and time data in order to perform their functions.
- B. Each item of date-sensitive equipment used in the project shall be warranted by the manufacturer to properly function and correctly use or process all time-related data for all dates and times which occur during a reasonable life expectancy of the equipment.

PART 3 - EXECUTION

3.03 INSTALLATION OF PRODUCTS AND EQUIPMENT

- A. Manufacturers' instructions: Except as modified by drawings or specifications, install products and equipment in accordance with manufacturers' instructions and recommendations applicable to the project conditions.

1. Immediately notify Architect if a difference or discrepancy is found between manufacturers' instructions and the drawings or specifications.

B. Install plywood backing panels with finished face exposed.

3.59 IDENTIFICATION

A. Items to be identified include, but are not limited to:

1. Voice and data communications systems and devices.
2. Video systems and devices.
3. Sound systems and devices.
4. Wire management equipment.

B. Identify function, equipment services, and area served.

3.61 TESTS

A. During the progress of the work and after completion, test the communications cabling and wiring systems.

B. Results of the tests shall show that the wiring meets the requirements of this specification. Should any test indicate defect in materials or workmanship, immediately repair, or replace with new, the faulty installation, and retest the affected portions of the work.

C. Furnish equipment and instruments necessary for testing.

D. Tests shall demonstrate the following:

1. Power, control, and system circuits are continuous and free from short circuits.
2. Circuits are free from unspecified grounds.
3. The resistance to ground of each non-grounded circuit is not less than one megohm.
4. Circuits are properly connected in accordance with the applicable wiring diagrams.
5. Circuits are operable.

E. Immediately repair defects and retest until systems are operating correctly.

F. Submit test reports.

3.81 OPERATING INSTRUCTIONS

A. Furnish the necessary technicians, skilled workers, and helpers to operate the communications systems and equipment of the entire project for one 8-hour day.

B. Where specified in technical sections, provide longer periods required for specialized equipment.

C. Instruct the Owner or designated personnel in operation, maintenance, lubrication, and adjustment of systems and equipment.

D. The Operating and Maintenance Manual shall be available at the time of the instructions for use by instructors and Owner personnel.

- E. Record each instruction session only in DVD media format (video and audio format), including both the sessions specified above and added sessions required in technical sections for specialized equipment. Provide one complete set of DVDs with each Operating and Maintenance Manual.
- F. Schedule the general and specialized instruction periods for a time agreed upon by the Owner and Architect.

END OF SECTION 270500

SECTION 271000 - LOW-VOLTAGE STRUCTURED CABLING SYSTEM

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including general and Supplementary Conditions, apply to this Section.

1.2 SCOPE

- A. Provide a complete system of wired voice, data, and projector AV outlets, suitable for distribution and utilization of data/voice network and AV signals from the Baltimore County Public Schools supplied telephone systems and computer data networks.
- B. The data network wiring shall be suitable for a minimum 1000 Mega-Bits per second (Mb/s) data network to all end devices, and 10Gbps between wiring closets.
- C. The data and voice structured cabling and outlet system shall include, but is not necessarily limited to:
 - 1. Category 6 Unshielded Twisted Pair (UTP) Data Cable
 - 2. Category 6 Unshielded Twisted Pair (UTP) Voice (Telephone) Cable
 - 3. Workstation Jacks
 - 4. Workstation Multi-Jack Outlets
 - 5. Wall mounted swing patch panel racks or stand-alone data cabinets/racks
 - 6. Type 110 Wiring Punchblocks for voice cables
 - 7. Category 6 Patch Panels for data cables – 48 port patch panels shall be used
 - 8. Complete system testing in accordance with accepted industry standard test means and methods
 - 9. Classroom high/low projector/teach AV cabling

1.3 STANDARDS

- A. Voice and data outlets, wiring and associated work shall be in strict accordance with the requirements of the Baltimore County Public Schools Department of Information Technology as indicated within this document.
- B. Cable television and video outlets, wiring and associated work shall be in strict accordance with the requirements of Comcast and Verizon cable TV standard and coordinated with Physical Facilities Electronics shop.

1.4 COLOR CODING

- A. All cabling, jacks, inserts and other system components shall be color coded to identify data versus voice (telephone) versus wireless facilities. Color codes shall be as specified below, in accordance with the standards set by the Baltimore County Public Schools Department of Information Technology.
- B. Color coding:
 - 1. Data wiring and jacks: Blue
 - 2. Wireless access point cabling and jacks: Purple/Violet
 - 3. Voice (Telephone) wiring and jacks: Gray

- | | |
|-------------------------------------|--------|
| 4. Fiber optics – multi mode (OM3): | Aqua |
| 5. Fiber optics – single mode: | Yellow |
| 6. Cable TV (if installed): | Black |
| 7. Emergency/alarm wiring: | Red |

1.5 SYSTEM DESCRIPTION

- A. System includes provision of combination data and/or voice single or multi-jack outlets at locations and in configurations indicated on the construction drawings, with station cables from each jack to the appropriate termination as specified herein.
- B. Typical workstation outlet configurations shall be as indicated in the schedule of telecommunications outlets on the drawings. Where both voice and data jacks are indicated to be provided in the same outlet, the voice jack shall be located at the upper left position. A typical setup shall consist of 1 voice, 2 data for teach/office/conference room setups, and 2 data purple/violet jacks in a faceplate that is mounted into the ceiling tiles.
- C. Wall mounted telephone outlets shall be provided with a single, flush mounted RJ-45 modular wiring jack mounted in a stainless steel wall plate with wall telephone instrument mounting lugs.
- D. Outlets designated on the plans for projector/teach station AV, otherwise known as high/low AV outlets, shall be installed according to section 3 of this standard. All distances for the cables between the high and low outlets must be within industry standard maximum lengths to ensure reliable signal transmission. Cable lengths must take into consideration the patch cords that will be required from the teacher's laptop/desktop/device to the low outlet, as well as any patch cords connecting the high outlet to the projector/presentation device.

1.6 SUBMITTALS

- A. Product data and shop drawings: Submit these items, and the Certifications specified below, as a complete package. Submittal will not be reviewed if it is incomplete.
 - 1. A complete schedule of equipment and materials that are to be furnished for the work. Accompanying the schedule shall be manufacturer's specifications or cut sheets for each major component.
 - 2. Complete drawings of equipment racks and special assemblies. Each drawing shall show all equipment with its manufacturer and model number.
 - 3. Complete drawings detailing installation locations of equipment, cable quantities and types with terminal block or patch panel locations.
 - 4. Certification reports for all low voltage wiring runs shall be emailed to gvukov@bcps.org, in Fluke Linkware format, or cvs for import into Baltimore County Public Schools DOT Information Services tracking system.
- B. Provide operation and maintenance manuals. Include complete service information, including schematics, prints of the Special System Drawings, interconnecting diagrams for this particular project, and parts lists to permit quick and efficient maintenance and repair of the equipment by a qualified technician. Provide a separate binder with copies of all system test reports.
- C. A schedule/count of data, phone, wireless, and other low voltage cabling/jacks for each closet must be submitted after the bids are issued so that a proper network design can be performed. This information is required so that the correct number of network switches can be designed and ordered for the project. This information must be provided to the BCPS Network Support Services Manager.

1.7 QUALITY ASSURANCE

A. Installer qualifications:

1. The installing contractor shall submit proof of having installed at least six similar data and voice structured cabling and outlet systems. These systems shall have been in service for a minimum of three years. These systems must have been within a fifty mile radius of the project location. Included with this proof shall be the customer name, customer contact and telephone number, and, if applicable, the architect and electrical engineer on the project. The Architect and Owner retain the right to reject any installing contractor who, in their sole judgment, has not met the above criteria or has received a less than favorable reference from any of the submitted references OR from any other customer for which the installing contractor has performed similar installations, whether or not such customer has been listed on the submittal.
2. In order to assure full compliance with all codes and regulations, the installing contractor must have on its regular staff a Master Electrician licensed within the jurisdiction in which the installation occurs. Proof of such licensing must be included with the original submittal.
3. The Contractor shall make application for all necessary permits, licenses and inspections as required by the Authority Having Jurisdiction, and shall pay all fees and charges appurtenant thereto.
4. The installing contractor must be certified by the manufacturer of the cabling system being proposed for installation. Proof of such certification must be included with the original submittal.

B. Manufacturer qualifications:

1. Materials proposed for use on this project shall be provided by a manufacturer experienced in manufacturing components listed and labeled under EIA/TIA-568A and who comply with these Specifications.

C. Comply with NFPA 70, "National Electrical Code."

D. Comply with the latest editions of following industry standards:

1. ANSI/EIA/TIA 568A Commercial Building Telecommunications Cable Standard
2. EIA/TIA 569A Commercial Building Standard for Telecommunications Pathways and Spaces
3. EIA/TIA 606 Administrative Standard for the Telecommunications Infrastructure of Commercial Buildings
4. EIA/TIA 607 Commercial Building Grounding and Bonding Requirements for Telecommunications
5. ANSI X3T9.5 Fast Ethernet 100Base-T LAN (FDDI): Defines standard for 100 Mb/s LAN based on either optical fiber cable or Unshielded Twisted Pair (UTP).
6. ANSI/BICSI 001-2009 Information Transport Systems Design Standard for K-12 Educational Institutions

E. Nationally recognized testing laboratory (NRTL) listing: System components of types and ratings for which NRTL listing or labeling service is established and components shall be listed and labeled.

F. Maryland State Department of Education Standards for Telecommunications Distribution – current version.

1.8 WARRANTY

A. Special warranty requirements:

1. The proposed systems will be covered by a two part certification program provided by a single manufacturer and that manufacturer's certified vendor. Manufacturer shall administer a follow-on program through the vendor to provide support and service to the purchaser.
2. The first part is an assurance program which provides that the certified system will support the applications for which it is designed, during the 15 year warrantee of the certified system.
3. The second portion of the certification is a fifteen-year warranty provided by the manufacturer and the vendor on all products within the system (cords, telecommunications outlet/connectors, cables, cross-connects, patch panels, etc.).
4. In the event that the certified system ceases to support the certified application(s), whether at the time of cut-over, during normal use or when upgrading (e.g. ATM), the manufacturer and vendor shall commit to promptly implement corrective action.

PART 2 - PRODUCTS

2.1 TWISTED PAIR CABLES, CONNECTORS, AND TERMINAL EQUIPMENT

- A. Station cables for data jacks shall be four pair Category 6 unshielded twisted pair (UTP), plenum-rated solid conductor cable conforming to the ANSI/TIA/EIA-568-B.2 Category 6 component specifications standards. Cable frequency capability shall be 250 MHz or greater (typically up to 500MHZ) and shall exceed IEEE 802.3ab and IEEE 802.3af. Extend two station cables from each jack to the location indicated in the Schedule of Telecommunications Outlets on the drawings, and terminate on Category 6 patch panel. Installation design and routing must ensure that a total length of cable is less than 90 meters.
- B. Station cables for voice jacks shall be four pair Category 6 unshielded twisted pair (UTP), plenum-rated solid conductor cable conforming to the ANSI/TIA/EIA-568-B.2 Category 6 component specifications standards. Cable frequency capability shall be 250 MHz or greater and shall exceed IEEE 802.3ab and IEEE 802.3af. Extend one station cable from each jack to the location indicated in the Schedule of Telecommunications Outlets on the drawings, and terminate on type 110 punch blocks. Neatly wrap all unterminated pairs at fax, modem, pay phone and similar outlets around the outer cable sheath for future use.
- C. UTP cable connecting hardware: Comply with EIA/TIA-568A, TSB 40. Insulation displacement connector (IDC) type, using modules designed for use with punch-down caps or tools.
 1. IDC terminal block modules: Integral with connector bodies, including plugs and jacks where indicated.
 2. IDC connecting hardware: Consistent throughout Project.
- D. Jacks and jack assemblies for UTP Cable: Modular, color-coded, RJ-45 receptacle units with integral IDC-type terminals.
- E. Workstation outlets: Multiple jack/connector assembly mounted in a single gang faceplate.
 1. Faceplate: High-impact modular white or ivory ABS plastic.
 2. Mounting: Semi-flush, except as otherwise indicated. All unused mounting spaces shall be equipped with a blank insert.
 3. Legend: Provide jacks in color corresponding to those specified above under "Color Codes." Label jacks, "Voice" or "Data" as appropriate to use. Provide facilities for insertion of machine printed jack identification label behind clear plastic cover. Install machine printed labels at each jack location.

4. Termination of station cables at voice and data jacks shall be in accordance with EIA/TIA 568A, Designation T568B for Category 6 cable. Verify jack termination scheme with Baltimore County Public Schools Department of Technology (contact Greg Vukov, Network Support Manager, at 410.887.3858 x. 497) prior to termination.
5. Wireless data drops – all locations calling for wireless access point cabling/jacks must have two drops installed per location. All cables must be home run to the nearest wiring closet on the same floor as the drop. At a minimum wireless access point drops should be installed in every classroom, offices, conference rooms, cafeteria, library, auditorium, gym (mounted at least 8 feet above finished floor – 2 minimum per gym – one on each side of the gym), and in every hallway spaced approximately 80 feet between each drop, and must follow the color coding indicated above. Outdoor wireless locations must be wired to using exterior rated CAT6 cabling. A minimum of one access point location (2 x drops minimum) at the front of the building, one or more to provide coverage to all parking lots and bus loops at the building, and one or two locations facing playgrounds, stadiums, and other outdoor areas where teachers and students may wish to use laptops/tablets/etc. for educational purposes.

2.2 DATA PATCH PANELS

- A. All data station cables shall be terminated in Category 6 patch panels.
- B. Patch panels shall be 48 port, Category 6, Hubbell or approved equal.
- C. Data patch panels shall be modular panel mounting multiple, numbered jack units with connectors of the IDC type at each jack to provide permanent termination of conductor pair groups of installed cables. Patch panels shall be Category 6 48 port as required to provide the necessary number of ports for the installation plus at least 20% spare ports (minimum fifteen empty ports) for future expansion.
- D. Mounting: Mount in equipment cabinets, with vertical and horizontal cable management brackets, as specified below.
- E. Appropriate number of patch cables must be supplied to allow all jacks, including wireless and data, to be patched down to BCPS supplied network switches and stations. Patch cables for the connection from patch panel to network switch are to be 7 feet; patch cables for connection from station jack to end device are to be 14 feet, all CAT6.

2.3 EQUIPMENT RACKS/CABINETS

- A. Wiring closets and main data room:
 1. Equipment racks shall provide EIA standard mounting provisions, with pre-drilled, pre-tapped
 2. holes to accommodate industry standard 19" patch panels and rack mounted equipment.
 3. For wall enclosure mounting: provide an APC AR100 or approved equal, 13 rack unit enclosure,
 4. fully enclosed with hinged, locking, safety glass front door, black, and hinged locking rear door. Rack shall include 120 volt, 100 cfm ventilation fan. Locate where indicated on drawings. (must be pre-approved prior to use within building – use #3 below as a standard)
 5. For floor enclosure mounting: provide an HP AF001A (10642-G2) or APC AR3100 or approved equal, 42 rack unit enclosure, complete with all front and side panels, and all required accessories. Rack shall include 120 volt, 100 cfm ventilation fan. Locate where indicated on drawings. See section 2.7 for more details on the room layouts.
 6. Provide complete horizontal and vertical cable management facilities in each rack.

7. Provide APC NET9RMBLK, or approved equal 120 volt power strip with minimum 9 NEMA 5-15R plug-in ports, within cabinet, as appropriate.
 8. UPS will be provided by BCPS DOT – requires at least one L5-30 outlet per rack/enclosure located within 6 feet of mounting location of UPS units, above the enclosures – see section 2.7 for more details on the room layouts
 9. All IDFs/MDFs, including the AC units within the rooms, must be on building wide generator.
- B. See 2.7 Data/wiring closet room layout for HVAC, additional electrical, lighting, cable tray, spacing, and other specifications.

2.4 FIBER OPTIC BACKBONE CABLES

- A. All wiring closets (IDF) will be interconnected to the main Data/Telco Equipment room (MDF) by 24 strand multi-mode fiber optic cable (OM3 - 50/125 micron) and 24 strand single-mode (9/125 micron) terminating into the enclosures marked “Wiring”.
- B. “SC” connector patch panels.

2.5 VOICE TERMINATION PUNCH BLOCKS

- A. Terminate voice cables on type 110 punch blocks. Voice termination punch blocks shall be AT&T 110-300 or approved equal. Provide a sufficient quantity of the required 110 type hardware to terminate all voice cables being installed under this contract. Provide all required stand-off brackets, D-Rings, and cable dressing hardware to provide, a neat and workmanlike installation. This is in preparation for a future VoIP phone system.
- B. In order to accommodate the installation of a future VoIP cabling system with existing non-VoIP telephones, the following must be provided: Station cables pulled and terminated to the data rack. Patch cords run from data rack to 110 blocks, punched down so that it provides access to all 4 cable pairs in each station cable. For more details please coordinate with Peggy Sullivan or Greg Creager – BCPS Telecommunications Section (410-887-4266 x. 465).

2.6 TV, VIDEO OUTLETS, CABLES AND MISCELLANEOUS EQUIPMENT

- A. Coordinate with Physical Facilities – David Kutcher (410-887-0470).

2.7 CLASSROOM PHONES/INTERCOM SYSTEMS

- A. Coordinate with Physical Facilities – David Kutcher (410-887-0470)

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements to receive cable. Check raceways and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Wiring methods:

1. Install station cables to individual outlets in raceway within walls.
 2. Install horizontal runs of station cables exposed above finished ceilings. Provide "J" hooks or other suitable cable management devices at intervals not to exceed 5'-0" on center.
- B. Install components as indicated, according to manufacturers' written instructions. Use techniques, practices, and methods that are consistent with the Category 6 rating of the components and that assure Category 6 performance of completed and linked signal paths, end-to-end.
- C. Install cable without damaging conductors, shield, or jacket.
- D. Do not bend cable in handling or installation to smaller radii than minimums recommended by manufacturers.
- E. Pull cables without exceeding cable manufacturer's recommended pulling tensions.
1. Pull cables simultaneously where more than one is being installed in the same raceway or cable run.
 2. Use pulling compound or lubricant where necessary. Use compounds that will not damage conductor or insulation.
 3. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage media or raceway.
- F. Install exposed cable parallel and perpendicular to surfaces or exposed structural members, and follow surface contours where possible.
- G. Secure and support exposed cable at intervals not exceeding 30 inches and not more than 6 inches from boxes, cable trays, fittings, racks, frames, and terminals.
- H. Separation of wires: Comply with EIA/TIA-569 rules for separation of unshielded copper voice and data system cables from potential EMI sources, including electrical power lines and equipment.
- I. Make splices, taps, and terminations only at outlets, terminals, and cross-connect and patch panels.
- J. Use splice and tap connectors compatible with media types.

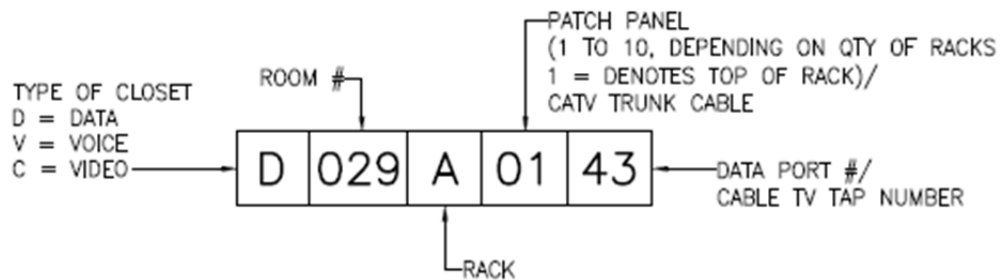
3.3 INSTALLATION AT EQUIPMENT ROOMS AND WIRING CLOSETS

- A. Provide adequate length of conductors and cables. Train the conductors to terminal points with no excess. Provide a minimum ten foot service loop for each copper cable within Equipment Room. Use cable management system to restrain cables, to prevent straining connections, and to prevent bending cables to radii smaller than allowed.
- B. Mount voice punch blocks, terminal strips, and other connecting hardware on plywood backboards, except as otherwise indicated. Provide additional 3/4-inch fire retardant treated plywood backboards where required for mounting of equipment.
- C. Mount data patch panels in floor or wall mounted electronic racks, with cable management. Do not fill racks to more than 50 percent capacity to allow spare room for Owner furnished equipment. Provide additional racks, to match existing, where required to maintain rack space.

- D. Group connecting hardware for cables into separate logical fields.

3.4 IDENTIFICATION

- A. Identify system components in compliance with the following specifications:
- B. Follow EIA/TIA recommendations and Owner's standards for identification of voice and data jacks, cables and terminations.
- C. Workstation: Label cables within outlet boxes. Label each jack with a unique identifying nomenclature



- D. Wireless access point cabling/cabling terminated above a ceiling must have the jack label applied to the ceiling grid, as well as the end termination point to allow for quick visual inspection by field network technicians for future troubleshooting. Preference is to have the wireless outlets terminated into a faceplate mounted to the ceiling tile where the wireless access points can be mounted directly to the faceplate.
- E. Distribution racks and frames: Label each unit and field within that unit.
- F. Within connector fields, in wiring closets and equipment rooms: Label each connector and each discrete unit of cable-terminating and connecting hardware.
- G. Cables, generally: Label each cable within 4 inches (100 mm) of each termination and elsewhere as indicated.
- H. Exposed cables and cables in cable trays: Label each cable at intervals not exceeding 15 feet (4.5 m).
- I. Cable schedule: Post at a prominent location in each IDF room and equipment room. List incoming and outgoing cables and their designations, origins, and destinations. Protect with a rigid frame and clear plastic cover. Provide a diskette copy of final comprehensive schedules for the project in the software and format as indicated in section 1.6.4.

3.5 SYSTEM ACCEPTANCE TESTING

- A. The cable system Installer shall document the cable system testing methodologies in detail, including the scope, procedures and acceptance criteria for testing. The testing process shall be comprised of the test cycles outlined below. All test results (e.g. cable lengths, test result values, etc.) shall be documented in both hard copy and electronic format for the Owner's review and approval. Electronic format shall be provided using one of the products available in the Microsoft Office Suite (Word, Excel, etc.), and shall be provided in format acceptable to BCPS.

- B. The cable system Installer shall provide all necessary diagnostic tools (i.e. Time Domain Reflectometer (TDR), cable scanner, meters, logging equipment, etc.) The Cable System Installer shall describe any testing tools that are used, along with the capabilities and limitations of these tools.
- C. Cable system testing shall be conducted before, during and after installation. Upon completion of all prerequisite tasks to the corresponding test, the cable system Installer shall notify the Owner in writing that the relevant portion of the cabling system is complete and ready for testing.
- D. Acceptance test failure: Failure of any portion of the cabling system to successfully complete an Acceptance Test shall be deemed a failure of the entire cabling system. Such events shall be cause for vendor obligation to execute the Retesting procedure outline below:
 - 1. If the cabling system, or any part thereof, fails an acceptance test, the cabling installer shall either:
 - a. Modify or adjust the cabling system to satisfy the necessary specifications and discrepancies;
 - OR-
 - b. Replace or add such components as may be necessary to make the cabling system satisfy the specifications.
 - 2. The cabling system installer shall notify the Owner in writing of the diagnosed problem, proposed method for correction, and then once the corrections have been completed of the readiness of the cabling system for re-execution of the acceptance test.
 - 3. Once all acceptance tests have been successfully completed, the cabling system Installer shall provide for the Owner's signature, a document indicating that the system has passed all acceptance tests and certifying the installation. This document will then be signed by the Owner as acceptance of the Cabling Installation and Acceptance Testing methodology and results.
- E. Cables systems acceptance tests:
 - 1. All copper cabling and terminations shall be tested, characterized and documented. At a minimum, the following tests must be performed:
 - a. Continuity testing shall be performed to determine that the copper conductors are continuous with no opens or shorts.
 - b. Cable characteristic testing shall be performed to measure the intrinsic characteristics of a copper cable segment. Information derived from this test shall include the cables near end crosstalk (NEXT), capacitance, and characteristic impedance. This test shall be conducted on all installed end-to-end cable sections.
 - c. Time domain reflectometer (TDR) shall be used to evaluate copper loss per unit length (Db/ft) to measure both the quality and length of copper cable. The TDR information shall be used to verify that the cable meets required IEEE 802.3 specifications for 1000BaseT connections over unshielded twisted pair cable.
 - d. Termination testing shall be performed after the cable has been installed to verify that all cable pairs have been properly terminated. This testing shall assure that the pin-outs are correct and that there have been no flipped or unterminated pairs.
 - e. Link confidence testing shall measure the copper cables ability to support 100 Mb/s (Fast Ethernet) and 1000 Mb/s (Gig Ethernet) (250Mhz or greater) transmissions.
 - f. Link confidence testing shall measure the fiber cables ability to support 100 Mb/s (Fast Ethernet), 1000 Mb/s (Gig Ethernet) (250Mhz or greater), and 10 gig Ethernet transmissions.

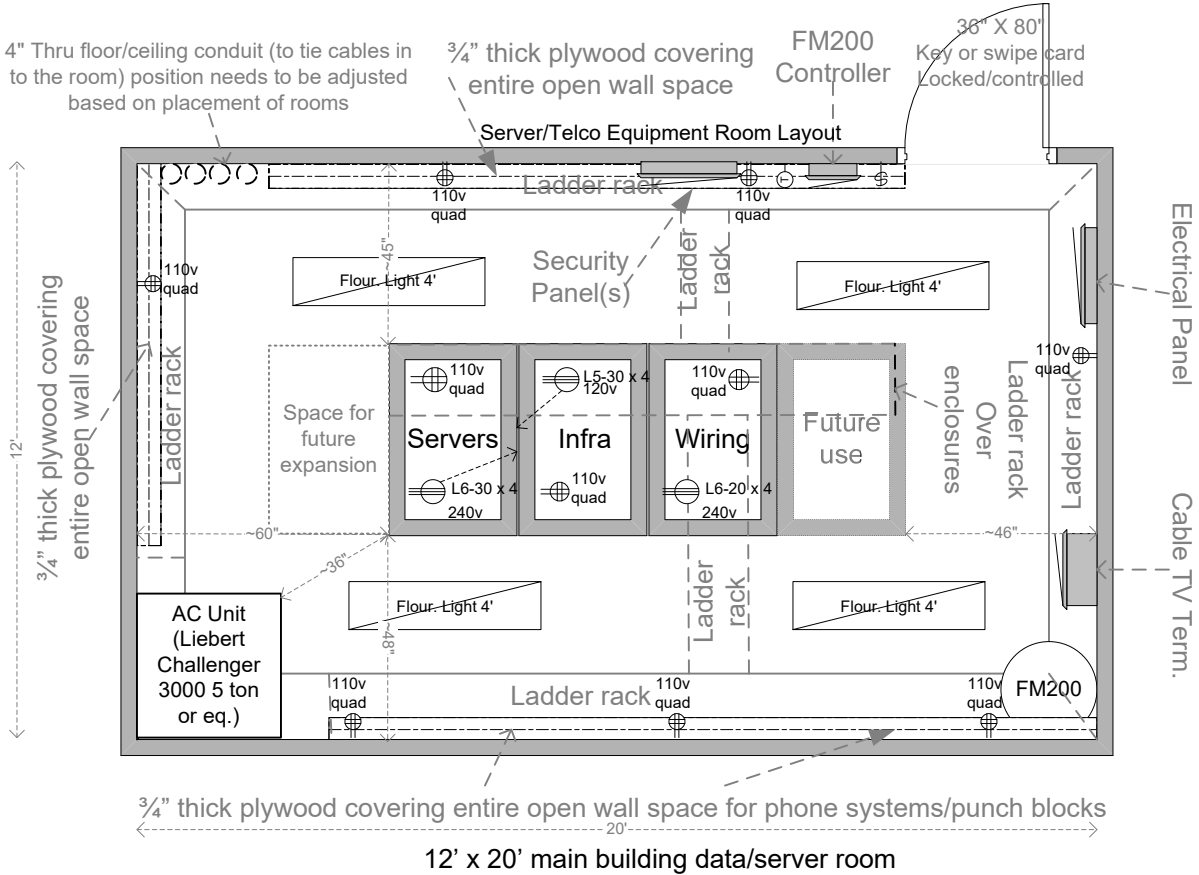
- g. Certification reports for all data wiring run shall be emailed to gvukov@bcps.org. Test results shall be provided in Fluke Linkware format, or cvs format for import into the Baltimore County Public Schools DOT Information Services tracking system. In addition, hard copies of each test report and a CD-ROM with all reports shall be included in the project operation and maintenance manual.
- h. The matrix below defines when each of the above tests shall be performed:

Copper Cable Test Requirements				
Unit Test Name	On-Reel	After Install	Post Term.	Final Test
Continuity Test		!	!	
Cable Characteristic Test				!
Time Domain Reflectometer (TDR)			!	!
Termination Testing			!	!
Link Confidence Test @100 Mb/s			!	!
Link Confidence Test @1000 Mb/s			!	!
Link Confidence Test @10000 Mb/s (fiber only)			!	!

3.6 CLEANING

- A. On completion of system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions from all areas worked in.

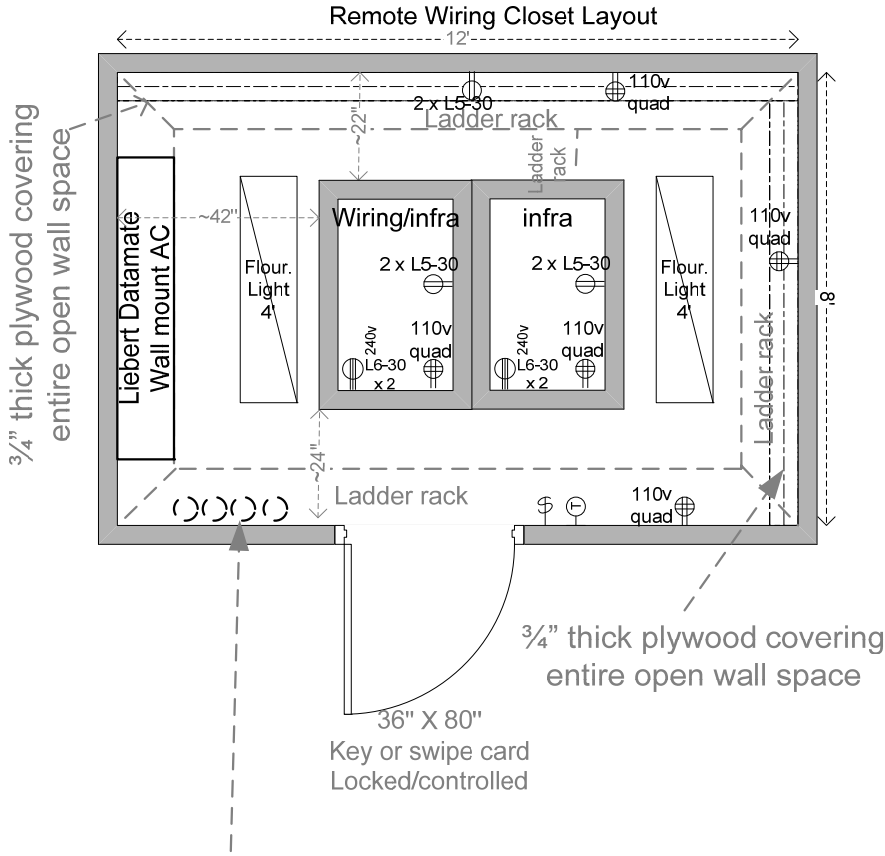
3.7 DATA/WIRING CLOSETS



Notes:

12' x 20' Data/Telco Equipment Room:

- 1: ladder rack around the 4 walls of the closet, with a connector ladder to the center of the enclosures
- 2: the eleven electrical outlets indicated above the enclosures are to be suspended from the ceiling to a height of ~85" above the floor – all outlets on separate circuits, on generator
- 3: this room requires L5-30/120volt, quad 5-20/120volt, L6-30/240volt, and L6-20/240volt electrical outlets (2 x quad 5-20, 4 x L5-30, 4 x L6-30, and 4 x L6-20) to be suspended from the ceiling to a height of ~85" above the floor, on separate circuits, and are NOT to be installed within the enclosures/racks. All outlets are to be on emergency generator.
- 4: need four fluorescent lights – two in front of the enclosures and two in the rear of the enclosures – lights are to be mounted at least 18" above the ladder racks and any wiring paths
- 5: requires its own environmental (AC/humidity) unit to control the heat and humidity within the room – temp < 75 degrees, humidity >=30% & <=50%, on generator
- 6: enclosures are to be HP 10642-G2 (p/n: AF001A) w/fan kit (p/n: 257413-B2), and side panels (p/n: AF054A), or APC AR3100, three initial enclosures, to be purchased and installed by the wiring contractor
- 7: room should have FM200, or other acceptable fire protection as this room will house the servers for all of the systems within the building, as well as the phone systems and core infrastructure equipment – value of the equipment in this room alone is \$200K+



4" Thru floor conduit (to tie cables in to the room) position needs to be adjusted based on placement of rooms

8' x 12' Remote wiring closet

Notes:

8' x 12' Floor/Remote Level Wiring Closets:

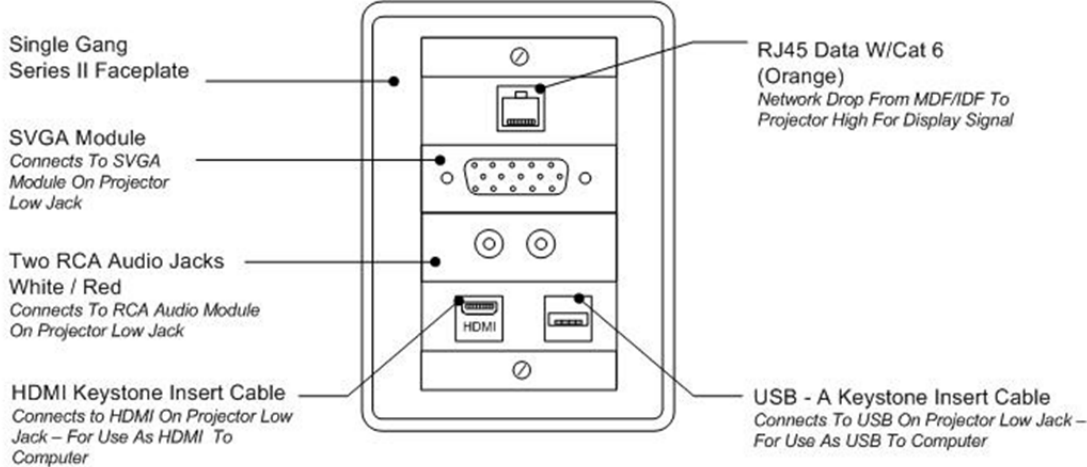
- 1: ladder rack around the 4 walls of the closet, with a connector ladder to the center of the enclosure
- 2: the five electrical outlets indicated above the enclosures are to be suspended from the ceiling to a height of 85" above the floor – all outlets on separate circuits, connected to building generator.
- 3: each closet requires its own environmental (AC/humidity) unit to control the heat and humidity within the closets
- 4: need two florescent lights – one in front of the enclosure and one in the rear of the enclosure – lights are to be mounted at least 18" above the ladder racks and any wiring paths
- 5: enclosures are to be HP 10642-G2 (p/n: AF001A) w/fan kit (p/n: 257413-B2), and side panels (p/n: AF054A), or APC AR3100, or approved equal, two enclosure per closet, to be purchased and installed by the wiring contractor
- 6: closets must be located as close to the center of the building and should be stacked on top of each other, in line with the main computer/telco room for the building for multi-story buildings, allowing for < 90 meters from closet to further data drop

General Notes for MDF, IDF, server and telecom rooms:

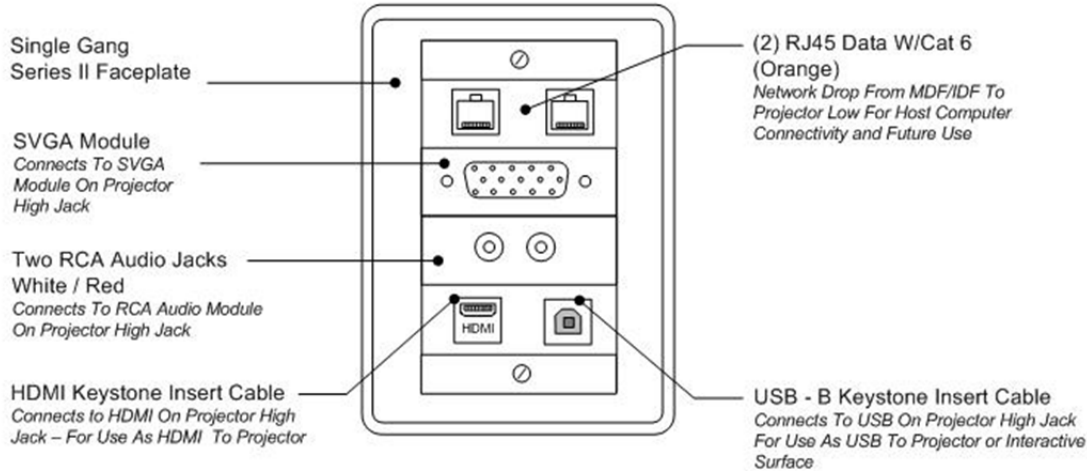
- 1: Backbone wiring: all wiring closets will be interconnected to the main Data/Telco Equipment room by 24 strand multi-mode fiber optic cable (50/125 micron OM3), 12 strand single-mode (9/125 micron) terminating into the enclosures marked "Wiring", with "SC" connector patch panels
 - 2: Horizontal wiring: all horizontal cabling within the building will follow the color coding indicated in section 1, CAT6 UTP Plenum solid conductor (see wiring specifications for details of data/voice wiring), and will be terminated into the enclosures marked "Wiring" using 48 port CAT6 patch panels, with cable management placed accordingly, in accordance with ANSI/TIA/EIA-568-B(.1, .2, .3), 568-3, 569-B, 598-C, and 758-A standards, using T568-B standard punch downs. Acceptable vendors for horizontal cabling components are: Corning, General Cable, Hubbell, Leviton, Molex, Nordx, Panduit, or Siemen. Frequency tests must exceed 250MHz and up to 500MHz for future capability.
 - 3: All cabling, horizontal and backbone, must be tested and certified by the installer, with electronic test results provided to Greg Vukov within 10 days of job completion, certifying to at least CAT6/250MHZ/1000Mbps on copper
 - 4: All wiring closets and the main data/telco equipment room must have a 36" x 80" door with at least key lock – preference is to have the doors controlled by a swipe card access method – keys are to be provided to BCPS DoIT – Greg Vukov, within 10 days of installation
 - 5: No false ceilings
 - 6: Lighting should supply at least 50-foot candles (540 lux) of illumination
 - 7: Ladder racks (data cable trays or wire ways) should be located at about 85" above finished floor
 - 8: all cabling must be labeled properly at both the station end and the closet termination point. Labels need to be resistant to environmental conditions and fading.
 - 9: Design must follow TIA/EIA-569 standards
 - 10: All doors should swing outward to allow for proper clearance and access to equipment within the rooms
 - 11: Grounding and bonding of equipment, ladder racks, and systems within the Equipment Room and wiring closets must conform to ANSI/TIA/EIA-607
 - 12: A minimum of 2 x L5-30 electrical outlets and 2 x quad 110v electrical outlets are required per rack/enclosure for connecting of the UPS units. All electrical should be mounted above the enclosures/racks as indicated above to ensure that power cables are not placed on the floor.
 - 13: All wiring closets must be connected to the building generator to ensure reliable, stable power during power outages affecting the building – the AC units within the wiring closets must also be connected to the building generator
 - 14: Wiring closets are only to be used to house IT infrastructure, i.e. cabling, switches, routers, phone systems, and authorized servers.
- 3.8 CLASSROOM HIGH/LOW PROJECTOR/TEACHER AV CONNECTIONS (PROVIDED BY TECHNOLOGY SUPPORT SERVICES)

Classroom Projector High/Low Faceplate Revisions
 BCPS Department of Technology

Revised: 02/14/2012
 Drawing By: Bill Groth

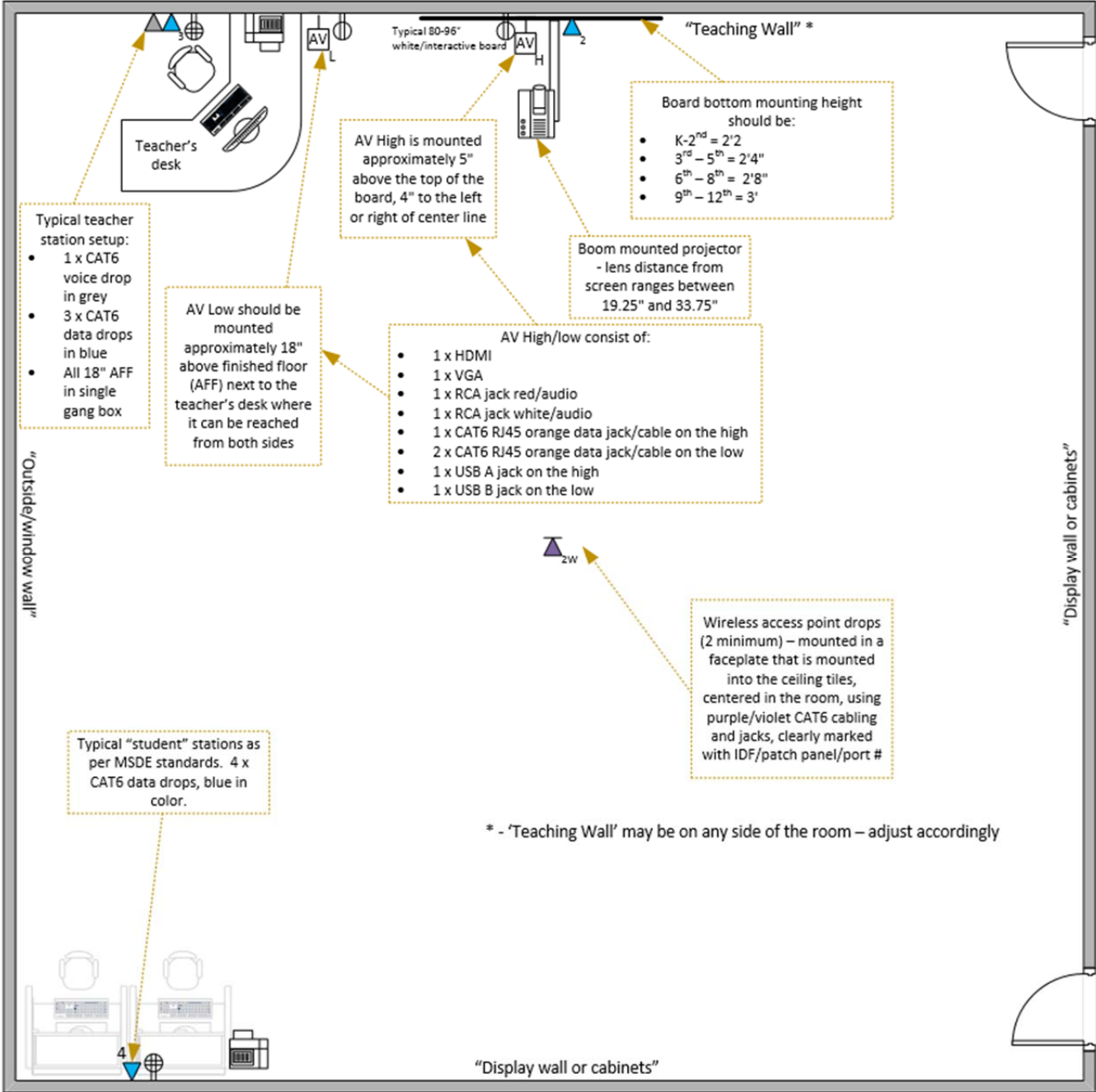


1. TYPICAL PROJECTOR HIGH OUTLET DETAIL

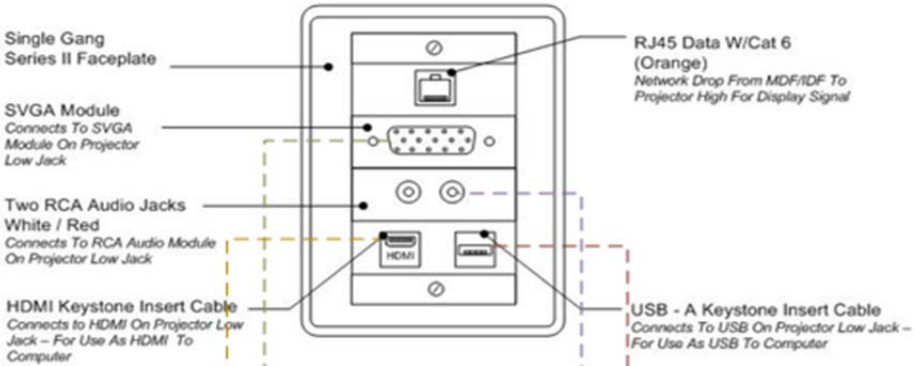


2. TYPICAL PROJECTOR LOW OUTLET DETAIL

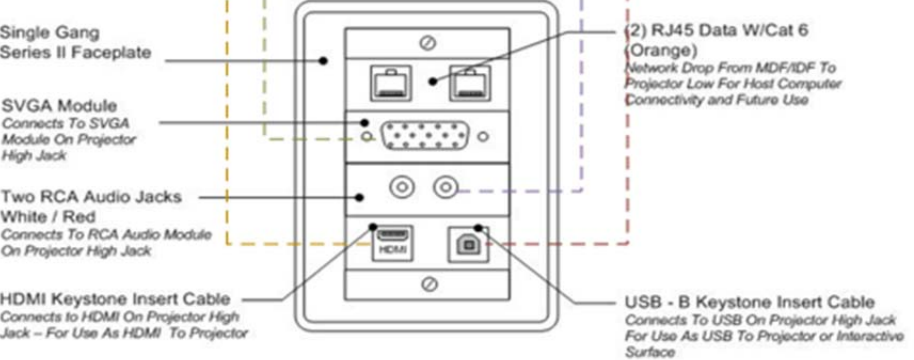
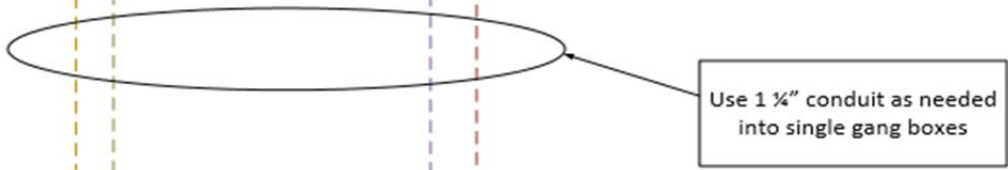
NOTE: These projector jack inputs are changing to reflect new digital industry standards. The HDMI connection is added to accommodate newer projection equipment and provide higher resolution. The USB jack is added to provide connectivity from computer to interactive projector or interactive whiteboard.



Typical Classroom Setup – Low Voltage Cabling



1. TYPICAL PROJECTOR HIGH OUTLET DETAIL



2. TYPICAL PROJECTOR LOW OUTLET DETAIL

END OF SECTION 271000

SECTION 273245 - PUBLIC SAFETY-FIRST RESPONDER RADIO AMPLIFICATION SYSTEM

PART 1 – GENERAL

1.11 SECTION INCLUDES

- A. This specification includes performance requirements for Public Safety and First Responder radio amplification systems in structures in accordance with the provisions of NFPA 1 - Uniform Fire Code.
- B. System shall be as approved by the State Fire Marshal and the local jurisdiction.
- C. System shall be provided in a full turn-key fashion. Locations of quantities and devices on drawings shall be verified and supplemented as required.

1.14 RELATED SECTIONS

- A. Division 26: Electrical.

1.20 REFERENCES

- A. The equipment and installation shall comply with the current provisions of the following standards:
 - 1. National Electric Code.
 - 2. National Fire Protection Association Standards:
 - a. NFPA 1: Uniform Fire Code
 - b. NFPA 72: National Fire Alarm Code
 - c. NFPA 101: Life Safety Code
 - 3. Local and State Building Codes.
 - 4. Local Authorities Having Jurisdiction.
 - 5. Underwriters Laboratories, Inc.: The system and all components shall be listed by Underwriters Laboratories, Inc.
 - 6. FCC.

1.21 DEFINITIONS

- A. The following definitions are applicable to this project.
 - 1. Authorized Company: A company that employs individuals that are qualified by the equipment manufacturer in writing to work on the repeater system.
 - 2. DAQ: Delivery Audio Quality Definitions: This is a universal standard often cited in system designs and specifications.
 - DAQ 1: Unusable, speech present but unreadable.
 - DAQ 2: Understandable with considerable effort. Frequent repetition due to noise/distortion.
 - DAQ 3: Speech understandable with slight effort. Occasional repetition required due to noise/distortion.
 - DAQ 3.5: Speech understandable with repetition only rarely required. Some noise/distortion.
 - DAQ 4: Speech easily understood. Occasional noise/distortion.
 - DAQ 4.5: Speech easily understood. Infrequent noise/distortion.

DAQ 5: Speech easily understood.

3. FCC: Federal Communications Commission.
4. OET 65 Standards: FCC's Bulletin 65 provides Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields.
5. Public Safety/First Responder: Public safety or first responder agencies which are charged with the responsibility of responding to emergency situations. These include, but are not limited to: Law enforcement department, fire departments, and emergency medical companies.
6. Radio Repeater: Component of a radio amplification system that receives a signal and retransmits that signal, helping the signal to travel over a greater range.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 270101.
- B. Product Data: Submit six complete sets of documentation within 30 calendar days after award of purchase order. Indicated in the documentation will be the type, size, rating, style, catalog number, manufacturer's name, photos, device address list, and/or catalog data sheets for all items proposed to meet these specifications. The proposed equipment shall be subject to the approval of the Architect and no equipment shall be ordered or installed on the premises without that approval. Provide hourly service rates and annual inspection prices, performed by factory trained and authorized personnel, with the submittal. Proof of that training and authorization of the servicing representative shall be included in the submittal. These hourly service rates shall be guaranteed for a one-year period unless otherwise specified.
- C. Shop Drawings: A complete set of shop drawings, one for each subassembly which requires that a field wire be connected to it, shall be supplied. The shop drawings shall be reproduced electronically from a master copy supplied by the manufacturer in digital format. Provide shop drawings as follows:
 1. Large scale drawing of the control panel and wiring diagram.
 2. Large scale drawing of the layout, configurations, and terminations.
 3. Single line riser diagram showing all equipment and type, number and size of all conductors.
 4. Large scale floor plan drawing showing device locations and types.
- D. All and any information and data (such as drawings showing device locations and types, riser diagrams, diagrams, approvals, battery calculations, sequence of operation, test data, etc.) required by local authorities. In addition to routine submission of the above material, make an identical submission to the authorities having jurisdiction. Include copies of annotated contract drawings as needed to depict component locations to facilitate review. Upon receipt of comments from the authorities having jurisdiction, submit them for review. Resubmit if required to make clarifications or revisions to obtain approval.
- E. Close-out Submittals: Two copies of the following manual shall be delivered to the building Owner's representative at the time of system acceptance. The close-out submittals shall include:
 1. Operation manuals covering the installed life safety system.
 2. Point-to-point diagrams of the entire system as installed. This shall include all connected and addressable field modules. All drawings shall be provided in CAD and supplied in standard .DXF format. Vellum plots of each sheet shall also be provided. A system generated point-to-point diagram is required to ensure accuracy.
 3. The application program listing for the system as installed at the time of acceptance by the building Owner and/or local AHJ (disk and hard copy printout).

4. Name, address and telephone number of the authorized factory representative.
 5. All drawings must reflect device address and programmed characteristics as verified in the presence of the Architect and/or the end user unless device addressing electronically generated, and graphically printed.
 6. Submit simultaneously with the closeout submittals, complete operation and maintenance manual listing, the manufacturer's name(s) including technical data sheets.
 7. Wiring diagrams shall indicate internal wiring for each item of equipment and the interconnections between the items of equipment. Drawings shall identify all terminals and illustrate all device wiring connections.
 8. Provide a clear and concise description of the operation that gives, in detail, the information required to properly operate the equipment and system.
- F. Certifications: Together with shop drawing submittal, submit a certification from the major equipment manufacturer indicating that the proposed supervisor of the installation and the proposed performer of contact maintenance is an authorized representative of the major equipment manufacturer. Include names and addresses in the certification.
- G. System operation description covering this specific project, including method of operation and supervision of each type of circuit and sequence of operations for all manually and automatically initiated system inputs and outputs. Manufacturers' standard descriptions for generic systems are unacceptable.

1.40 QUALITY ASSURANCE

- A. Qualifications: The installer shall provide proof of their qualifications to be factory authorized and factory trained for the product(s) specified herein. These qualification credentials shall not be more than two years old, to ensure up to date product and application knowledge on the part of the installer.
- B. Warranty: Warranty all materials, installation and workmanship for three years from date of acceptance, unless otherwise specified. A copy of the manufacturer's warranty shall be provided with closeout documentation and included with the operation and installation manuals.
- C. Compliance with local requirements: Comply with the applicable building code, local ordinances, and regulations, and the requirements of the authorities having jurisdiction.
- D. The installation of the radio amplification system shall be supervised by the systems equipment manufacturer.

1.80 WARRANTY

- A. Manufacturer shall guarantee the system equipment for a period of two years from the date of final acceptance of the system. The full cost of maintenance, labor and materials required to correct any defects during the two-year period shall be included in the submittal bid. Warranty service shall be provided by a trained specialist of the equipment manufacturer who shall be based in a fully staffed, fully stocked (replacement parts and test equipment) branch office, located within 50 miles of the site.
- B. The Contractor shall guarantee all wiring and raceways to be free from inherent mechanical or electrical defects for one year from date of final acceptance of the system.

- C. Upon completion of the installation of the radio amplification system equipment, provide to the Architect a signed written statement, substantially in the form as follows: "The undersigned, having engaged as the Contractor on the project, confirms that the system equipment was installed in accordance with the wiring diagrams, instructions and directions provided to use by the manufacturer.

PART 2 – PRODUCTS

2.10 GENERAL

- A. The system design and installation shall in no case exceed the FCC's OET 65 Standards.
- B. Minimum signal strength and coverage: For the purposes of this section, adequate radio coverage shall be designed in accordance with the following:
 - 1. System shall be designed to provide a minimum signal level of -95 dBm for two-way coverage (both talk-out and talk-in) on each floor, and shall be available in 95 percent of each floor's area. Coverage shall also be provided for any mechanical penthouses, elevator machine rooms, etc., located at the top of the structure.
 - 2. Critical rooms, including but not limited to, such areas as fire command center, fire pump room, emergency generator room, stairwells with a standpipe, and other staging areas as identified by the Fire Department shall have a minimum signal level -95 dBm for 98 percent of the room.
- C. Reliability factor: The system shall be designed and capable of providing a 95 percent reliability factor.
- D. Supported frequencies: The radio system shall support frequencies in the 700 and 800 megahertz public safety bands as utilized by public safety and first responder agencies.
- E. Reject filters: Notch filter sections shall be incorporated to minimize adjacent channel cellular and SMR (Nextel) degradation of the signal booster performance. The minimum downlink bank adjacent band ejection shall be 35 dB or greater at 85645 MHz and 870 MHz.
- F. Band migration capability: The signal booster shall include re-tunable or replaceable filters to accommodate rapid and economic passband changes in the event of a mandatory FCC changes within the 806-824 and 851-859 MHz band. The use of non-adjustable and non-replaceable RF input and output filters is prohibited.
- G. Output level control: An automatic output leveling circuit shall be included for both passbands with a minimum dynamic range of 60 dB, less any gain reduction setting, to maintain FCC out of band and spurious emission compliance.
- H. Degraded performance in emergencies: The system shall be designed to allow degraded performance in adverse conditions, such as abnormally high temperatures resulting from nearby fires, extreme voltage fluctuations or other abnormal conditions that may occur during an emergency. Circuits that intentionally disable the signal booster in such situations (i.e., under/over voltage, over/under current, over/under temperature, etc.) will not be implemented as the standard mode for public safety applications. It is the purpose of this specification to assure the maximum possible level of communications to public safety personnel depending upon the signal booster, even to the extent of damaging the signal booster as long as some communications benefit can be provided during the emergency.

- I. Mode of operation: The system shall be normally powered on and shall continuously provide passing of frequencies within the Public Safety and First Responder bands.

2.65 SYSTEM COMPONENTS

- A. Compatibility: The equipment, including but not limited to repeaters, transmitters, receivers, signal boosters, cabling, fiber distributed antenna system, etc., shall be compatible with the existing communication systems utilized by the Public Safety and First Responder agencies.
- B. Power Supplies: Any part of the install systems which contain electrically powered components, the systems shall be capable of operating on the emergency generator system, if provided, and an independent battery system. The power sources shall meet the requirements of Level 1, Type 10, Class X system of NFPA 110. The battery system shall be provided such that the system is capable of continuous duty for four hours in the event of primary and generator power failure. Systems, where an emergency onsite generator is not present, shall provide battery capacity of twelve hours of continuous duty.
- C. Survivability:
 - 1. Physical protection: Wiring and fiber optics shall be installed in conduit.
 - 2. Fire Performance: Main risers or trunks of the antenna system shall be installed with resistance to attack from a fire using one of the following methods:
 - a. A two-hour fire-rated cable or cable system.
 - b. Routing the cable through a two-hour fire-rated enclosure or shaft.
 - c. A system configured in a looped design, routed through one-hour fire-rated enclosure or shaft. The circuit shall be capable of transmitting and receiving a signal during a single open or non-simultaneous single ground fault on a circuit conductor.
 - d. Performance alternative approved by the authority having jurisdiction. Laterals to individual antennas do not have to be protected by a fire-rated enclosure.
- D. Cabinet: The signal booster and all associated RF filters shall be housed in a single, NEMA 250 Type 4 certified, painted steel weather-tight box. The cabinet shall be large enough to dissipate internal heat without venting the inside of the cabinet to the outside atmosphere. External or exposed RF filters are unacceptable.
- E. Operating temperatures: Minus 22 deg F to plus 120 deg F (minus 30 deg C to plus 50 deg C) minimum temperature range, including microprocessors. Equipment installed on the roof of structures shall be rated for the expected extreme temperatures associated with rooftop installations.
- F. FCC requirements: Active equipment (signal boosters and bi-directional amplifiers) shall meet FCC requirements.
- G. Passive equipment: Passband shall be 700-900 MHz, IP rating of 2 Ghz.
- H. Cable: Passband shall be 700-900 MHz. Cable shall be rated for fire plenum and riser rating.

2.94 LICENSING

- A. All fire department radio frequencies will be FCC licensed under the Baltimore County system. All fees associated with the licensing shall be paid by the property owner.

- B. All testing must be done on frequencies authorized by the FCC. A valid FCC license will be required if testing is done on frequencies different from the police, fire, or emergency medical frequencies.

PART 3 – EXECUTION

3.05 APPROVAL AND TESTING PROCEDURES

- A. Design Approval: Plans shall be submitted and approved prior to installation. The following information shall be provided:
 - 1. Detail drawings showing the location the amplification equipment and associated antenna systems which include a view showing building access to the equipment; and
 - 2. Schematic drawings of the electrical systems, backup power, antenna system and any other associated equipment relative to the amplification equipment, including panel locations and labeling.
 - 3. Manufacturer's data sheets on equipment to be installed.
- B. Commissioning Test: It is the building Owner's responsibility to ensure that a commissioning test of the radio repeater system occurs prior to occupancy for the building. The test shall ensure that two-way coverage on each floor of the building meets the minimum coverage requirements described above.
- C. Tests shall be made using frequencies close to the frequencies used by the Fire Department and appropriate emergency services. If testing is done of the actual frequencies, then this testing must be coordinated with the State Fire Marshal. All testing must be done on frequencies authorized by the FCC. A valid FCC license will be required if testing is done on frequencies different from the police, fire, or emergency medical frequencies.
- D. Testing Procedures:
 - 1. Minimum signal strength: For testing system signal strength and quality, the testing shall be based on the DAQ system. A DAQ level below 3.0 shall be considered a failed test for a given grid cell.
 - 2. DAQ shall be subdivided into a grid system consisting of 40 equally spaced grids for testing. The number of grids shall be adjusted such that the grid spacing is not less than twenty-five feet, nor shall it exceed more than fifty feet. Signal strength measurements shall be taken at the center of each grid.
 - 3. A maximum of two nonadjacent grid cells will be allowed to fail the test. In the event that three of the areas fail the test in order to be more statistically accurate, the testing grid resolution may be doubled. A maximum of four nonadjacent grid cells will be allowed to fail the test. If the number of grid cells is adjusted to meet the spacing requirements of Item 2 above, the number of failed cells permitted shall be adjusted accordingly to meet the 95 percent coverage requirement.
 - 4. Failures shall be allowed in critical areas, including but not limited to, the fire command center, fire pump room, emergency generator room, stairwells with a standpipe, elevator lobbies serving the emergency elevator, and other areas as identified by the fire department.
 - 5. Both inbound and outbound signals shall be measured on each and every floor above and below ground; including stairwells, basements, penthouse facilities and parking areas of the structure.
 - 6. Measurements shall be made with the antenna held in a vertical position at three to four feet above the floor (portable radio worn on the belt or turnout coat pocket).

- E. Pre-Testing: It is the building Owner's responsibility to have the radio system pre-tested to ensure that two-way coverage on each floor of the building meets the minimum coverage described above.

- F. Acceptance Testing:
 - 1. All acceptance testing shall be done in the presence of the State Fire Marshal.
 - 2. Small scale drawings (11 x 17 maximum) of the structure shall be provided by the Owner/Contractor. The plans shall show each floor divided into the grids as described above, and the results of the pretesting. The plans shall show each floor divided into the grids as described above. Each grid shall be labeled to indicate the DAQ result from the commissioning test.
 - 3. The Owner/Contractor shall provide the latest approved plans for the system, including any manufacturer's data sheets for any equipment changes not submitted in the original submittal.
 - 4. All testing results of the repeater (output wattage, gain level, etc.).
 - 5. The Owner shall provide written documentation certifying that an acceptable sweep test to measure the level of RF radiation has been conducted and that the antennae system complies with FCC OET 65 Standards.

3.65 MAINTENANCE AND ANNUAL TESTING

- A. Maintenance and servicing: Provide maintenance contract in place with name of authorized company, who will provide a 24-hour by 7 day emergency response within two hours after notification. The system shall be maintained in accordance with FCC requirements. Maintenance contract shall include annual testing with all active components of the system, including but not limited to, the amplifier, power supplies, and back-up batteries. Amplifiers shall be tested to ensure that the gain is the same as it was upon initial installation and acceptance. The original gain shall be noted and any changes in gain shall be documented. Active components shall be checked to determine that they are operating within the manufacturer's specifications for their intended purpose. Documentation of the test shall be maintained on site and a copy forwarded to the Baltimore County Fire Department upon completion.

- B. Maintain a list of contact personnel with phone numbers at the radio repeater system cabinet. The contact personnel shall have knowledge of the building and the repeater system and be available to respond to the building in the case of an emergency.

END OF SECTION 273245

SECTION 275116 - INTERCOM/PUBLIC ADDRESS AND MASTER CLOCK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Replace existing intercom/public address system with new.
2. This section and associated drawings define a communications system for an intercom, public address and master clock system that utilizes the facility fiber backbone.
3. The contractor shall provide all infrastructure, cable, hardware and equipment as defined to provide a complete and operational system.

1.2 SYSTEM DESCRIPTION

A. Design Requirements

1. Intercom/PA System

- a. The facility intercommunication system shall be a low voltage system that utilizes a copper cable and fiber backbone infrastructure to distribute a user-defined input in a single or bi-directional manner.
- b. The system shall use copper cable between room devices and head-end control units.
- c. The system shall utilize the building data network/fiber backbone to distribute signals across the facility.
- d. The system shall be capable of multiple, simultaneous conversations on separate channels throughout the facility through telephones and loudspeaker assemblies.
- e. A programmable master for tone distribution schedule shall also be included as part of the overall system.
- f. The system shall be microprocessor based and interconnect with the VoIP telephone system installed within the facility. In addition, the system must be expandable to meet the user's future expansion needs and be programmable from a computer terminal located at the facility.

B. Performance Requirements

1. Rack/Cabinet mountable equipment
2. Announcement distribution from a central location to zones, individual classrooms, groups or all facility speakers
3. Broadcast of user defined input (radio signal, compact disc, aux input, etc.) to zones, individual rooms, groups or all facility loudspeakers
4. Emergency cut-in to all speakers in an emergency situation from a central location
5. Two-way intercommunication between rack equipment, any call-in location or any selected two-way speaker location
6. Hands free communications by means of a loudspeaker or speakerphone used as a transducer or speaker/microphone combination
7. Visual and audio monitoring of all intercommunication system activity
8. Volume and level controls for all centrally located intercommunication system equipment
9. Tone distribution based off the master clock that can be partitioned into zones
10. Capability to tie into any auxiliary sound system throughout the facility
11. High priority call-in from any telephone in an emergency situation
12. Interconnection with the VoIP telephone system

C. REGULATORY REQUIREMENTS

1. All work will conform to the National Electric Code and applicable local ordinances.

1.3 SUBMITTALS

- A. Comply with requirements of Division 00 and Division 01 - Submittals and as modified below.

- B. Product Data: Submit manufacturer's product literature, technical specifications and similar information for the following items demonstrating compliance with the specified requirements.

1. Submit the shop drawings, product data and quality control submittals specified below at the same time as the package
2. Shop Drawings shall include the following items but are not limited to:

- a. Wire types
- b. System wiring diagrams showing all connections
- c. Drawings including all equipment locations
- d. Associated equipment specifications and cut sheets
- e. Product data including catalog cut sheets, manufacturer's default specifications, user operation guides and a bill of materials

C. Quality Control Submittal

1. Submit the name, address and telephone number of the nearest fully equipped service organization.
2. Submit a certificate of completion of installation and service training from the system manufacturer.
3. Certificates

- a. Manufacturer Certification: Submit certification from manufacturer of products to be installed under this contract certifying that Installer is authorized by manufacturer to install specified products.
- b. Installer Experience Listing: Submit list of at least 5 completed projects as specified below in "Quality Assurance – Qualifications – Installer."

- D. Contract Closeout Submittal: Comply with requirements of Division 00, including submission of operating and maintenance instructions as item in "Operation and Maintenance Data" manual described in that Section.

1.4 QUALITY ASSURANCE

- A. All Work shall be installed in a first class, neat and workmanlike manner by skilled Technicians. The quality of the workmanship shall be subject to inspection and approval by authorized BCPS personnel. Any work found to be of inferior quality and/or workmanship shall be replaced and/or reworked until the approval of BCPS is obtained.

B. Qualifications

1. Installer

- a. Must be qualified to cable, terminate, install and program the equipment specified in this Section, certified by manufacturer of products to be installed, and completed at least 5 installations of similar size, nature and complexity as specified for this project.

1.5 WARRANTY

- A. Special Warranty: Provide manufacturer's system warranty against electrical or mechanical defects for 1 year from date of final acceptance.
 1. System Assurance: The System Assurance shall cover the failure of the wiring system to support the application which it was designed to support as well as additional application(s) introduced in the future by recognized standards or user forums
 2. System Certification: Upon successful completion of the installation and subsequent inspection, the Authority shall be provided with a numbered certificate, from the manufacturing company, registering the installation.

1.6 TRAINING

- A. Installing contractor shall provide a minimum of 8 hours of training on system operation and managements as part of their scope of work.
 1. Additional hours shall be provided on a time and materials basis at the request of the owner.
- B. Installing contractor shall provide a video recording on a standard format DVD to the owner which includes training sessions.

1.7 OPERATION AND MAINTENANCE MANUALS

- A. Installing contractor shall provide a minimum of two hardcopy and one electronic copy of all operation and maintenance manuals to the owner at project completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. ACCEPTABLE MANUFACTURERS
 1. The following performance specification is based on the Rauland-Borg Telecenter 21 which is standardized throughout the county school system. Provide a new Telecenter 21 only, no substitute. All specified items, functions, and quantities are critical to the operation of the school and must be provided exactly as specified. Rauland-Borg (847-679-0900) products may be purchased from distributors in Maryland, Pennsylvania, Delaware and northern Virginia.

2.2 MATERIALS

- A. PRODUCT OVERVIEW
 1. Intercom system equipment.
 2. Supply and install a complete microprocessor based Public Address, Intercom and Master Clock system for bell schedule. The system shall be a Rauland Telecenter 21 system.
 3. Administrative Display Telephone: Rauland Telecenter 21 model.
 4. Rack System: Rauland Telecenter 21 model.

- a. Provide a separate circuit for each classroom and administrative office so each room can be individually addressed
5. Telephone Interface Module: Rauland Telecenter 21 model.
 6. Secure Call Switch: Rauland Telecenter 21 model.
 7. Program Sources
 - a. Provide an AM/FM CD player,
 8. Equipment racking:
 - a. The electronics equipment shall be contained in an upright rack, Telecor model 242, 261 or 277 or approved equal. The rack must be sized by the contractor to house all components required by this specification plus 20% spare for additions.
 - b. The rack shall be 21.9" wide and 18.5" deep. It shall be constructed of CRS, using 16-gauge material for the top and bottom of the rack and 14-gauge material for the sides. The rack shall be equipped with both front & rear mounting rails, punched on standard EIA centers. The rack shall be complete with a hinged, locking rear door. The rack shall be finished in Black Baked Enamel.
 - c. The rack must be supplied with locking castors to enable movement if necessary.
 9. Administrative handsets:
 - a. The intercom/paging system control console shall be microcomputer based, desk top console, occupying no more than 75 sq. inches of desk space and weighing 2 lbs. It shall be manufactured of high impact, molded plastic with a standard 12 button keypad. It shall be a Rauland Model.
 10. Clocks
 - a. Sapling SMA 3000 Series wireless master clock, rack mounted, with integral wireless transmitter/repeater, four zones, and web interface software.
 - b. Stand-alone wireless repeater: Sapling SMA-1SR-0000-1.
 - c. Analog wireless clocks: Sapling SAL-2 Series, 12-inch clock size.
 - d. Digital wireless clocks: Sapling SBL-3000 Series, 4-inch display, 4-digit display, 24-volt power connection, plastic double-mount housing for two digital clocks.
 11. Intercom handsets
 12. Volume control:
 - a. A volume control dial shall be included with each call switch in administrative and office areas. See drawings for locations.
 - b. The volume control dial shall be mounted inline, directly above the call switch.
 - c. The volume control dial shall be the Rauland ACC1300, or approved equal.
 - d. The volume control dial shall be compatible with the system architecture.
 13. Rugged call switches:
 - a. In areas that are a hostile or rugged environment a tamper-proof call switch shall be provided.
 14. Speakers

- a. The loudspeaker assembly shall be the Rauland BAFKIT1X2SVC assembly drop-in ceiling speaker with integrated volume control.
- b. Corridor speakers shall include Atlas 60-8 Satin Aluminum finish baffle with enclosure and Atlas 81-8S Tile Bridge. Mock up is required for approval prior to purchase.
- c. Surface ceiling mounted speakers shall be Rauland ACC1207 with vandal-resistant speaker assembly consisting of Rauland USO188 eight-inch loudspeaker and Rauland ACC1113 backbox, or approved equal..

15. Horn Loudspeaker

- a. The horn-type loudspeaker shall be Atlas VT-152UCN
- b. Interior horn-type loudspeaker shall be Rauland 3607 with ACC1118 backbox and ACC1014 baffle, or approved equal.

16. Remote Interface

- a. Provide and install a remote interface in the main office area to control the AM/FM CD player and auxiliary input functions of the Intercom System.

17. Cable Types

- a. PA Cable shall be 4 Conductor 18 AWG (2 Shielded, 2 Unshielded)
- b. PA Cable shall be Category 6 type cable
- c. PA System shall utilize building backbone fiber.
- d. PA Cable shall be plenum or non-plenum as required by code.
- e. PA Cable shall be yellow Berk-tek 10032531 or approved equal
- f. PA Cable must be presented to the school district for approval prior to installation.

2.3 CAFETERIA AND GYMNASIUM SOUND SYSTEMS

- A. General: The Cafeteria and Gymnasium sound system serves a variety of events, including lectures, classes, narrations, and motion picture reproduction.

1. The following functions are provided:

- a. A "Lecture" mode of operation.
- b. Reinforcement of live or recorded events.
- c. Archival recording of events.

2. Microphone, projector and auxiliary input receptacles shall be located in various positions and connected to the Cafeteria mixer.

B. Microphones and accessories

- 1. General: Outputs of all microphones shall be 150/200 ohms, balanced with respect to ground. Each microphone shall be supplied with two 25-foot flexible cables. Cables shall be terminated with plated, 3-contact, "XLR" type male and female connectors.
- 2. Unidirectional dynamic microphones: Cardioid directional pattern, with 10 dB or greater front-to-back discrimination from 100 to 8,000 Hz. On axis frequency response within + 2.5 dB, 100 to 15,000 Hz. Supply with hardware for floor stand and desk stand mounting.
 - a. Equal to Rauland Model 1285.
 - b. Quantity: Provide three, with floor stands.

3. Unidirectional surface-mounted microphone: Half cardioid directional pattern, with 10 dB or greater front-to-back discrimination from 100 to 8,000 Hz. On axis frequency response within + 2.5 dB, 100 to 15,000 Hz. For "footlight" or other surface-mounted applications.
 - a. Acceptable: Crown PCC-160 or Audio Technica AT871R or Shure SM-91.
 - b. Quantity: Provide two.

4. Hanging microphones: Hypercardioid (shotgun) directional pattern. For hanging applications, supplied with hanging and aiming hardware. Frequency response shall be 100 to 15,000 Hz.
 - a. Acceptable: Audio Technica AT933PM/ML
 - b. Quantity: Provide three at locations indicated on the drawings.

- C. Control and signal processing equipment (Cafeteria):
 1. The mixer-amplifier(s) shall have six mixer input ports (expandable to twelve). Each port shall be usable with a microphone or high level devices. The mixer-amplifier mainframe shall include a compressor/limiter, low and high frequency shelving equalizers, and a sound generator capable of producing general purpose and emergency warning tones. The power output shall be 150 watts at less than 0.05 percent THD from 20Hz to 20kHz direct output, or 50Hz to 20kHz transformer output. Frequency response shall be within 1dB from 20Hz to 20kHz direct output, or from 20Hz to 15kHz transformer output. Source impedance shall be 150 to 250 ohms nominal with a microphone preamplifier, 600 ohms with a bridging transformer, 150 to 600 ohms with a line matching transformer, and greater than 30 k ohms with a tape preamplifier. Load impedance shall be 4 ohms, 4.2 ohms (25V line), 8 ohms, or 33 ohms (70V line). Output voltage shall be 24.5, 25, 34.6, or 70.7 volts rms. Equivalent input noise shall be -124dBm with a low impedance microphone preamplifier. Output noise shall be at least 105dBm below rated output when all controls are off. Amplifier shall provide phantom power to microphones. The mixer-amplifier shall be rack-mountable.
 - a. Equal to Altec 1715C with 1700C expansion chassis as required.
 - b. Quantity: Provide one unit per system with one input for each input source indicated on drawings, and rack-mounted source equipment.

 2. The equalizer shall have 28 constant-Q active band-pass filters at the ISO preferred 1/3 octave center frequencies from 31.5 Hz to 16 kHz. Each filter shall provide up to 12 dB of boost or cut at its center frequency and shall be designed to skirt with adjacent filters for minimum ripple and optimum combining characteristics over a wide range of control settings. The amount of boost or cut shall be controlled by center detented linear slide type controls. A front panel control shall provide 20 dB of gain to restore equalization losses. The equalizer shall also contain 18 dB/octave high-pass and low-pass filters from below 20 Hz to 160 Hz for the high-pass and 5 kHz to above 20 kHz for the low-pass. The equalizer shall meet the following criteria: Frequency response: 20 Hz -20 kHz, +0, -1 dB referenced at 1 kHz. Operating gain: 0 dB. Dynamic Range: greater than 110 dB. THD: less than 0.03 percent with 0 dBm output at unity gain. IMD (SMPTE): less than 0.03 percent with 0 dBm output at unity gain. Noise: less than -85 dBm A-weighted at unity gain.
 - a. Equal to Altec 1431, Electrovoice 2710, or IRP DG4023.
 - b. Quantity: Provide one per system, with a metal security cover assembly.

3. Provide a digital signal delay with output suitable for use with the area served by the delay loudspeakers. The front panel shall exhibit a display with time delay readout. The signal delay shall meet or exceed the following specifications: frequency response, 20 Hz - 20 kHz, +0.5/-2dB; signal to noise ratio greater than 86 dB; dynamic headroom of 106 dB; balanced input and output. The unit shall provide control function lockout for tamper-resistance of programmed settings.
 - a. Digital signal delay shall be equal to Altec 1742A.
 - b. Quantity: Provide one unit in the Cafeteria system cabinet.

D. Loudspeakers and associated equipment

1. Cafeteria and Gymnasium main loudspeakers shall be Altec model 9872 two-way constant directivity loudspeaker units with grilles. The high frequency horns shall have a dispersion angle of 110 degrees horizontally and 60 degrees vertically. The horn arrangement shall be asymmetric in design to allow the cabinet back to be placed flat against the wall and the horn directed downward. The sound pressure sensitivity (SPL) shall be 99.5 db (1 watt -one meter) and the long term power handling capacity shall be 150 watts, 80Hz -20KHz. The cabinet of the loudspeaker shall be cabinet grade birch. Loudspeakers shall be engineered for permanent, suspended applications. Loudspeakers shall be omni-mounted on the wall with ball and socket assemblies, according to the manufacturer's installation specifications.
2. Cafeteria: Two loudspeakers, located on each side of the front proscenium wall, shall provide directional realism of reinforced sound.
 - a. One-third octave equalization shall maximize the system's gain before feedback and provide overall smooth response.
 - b. Compressor/limiter shall protect loudspeaker components.
 - c. Digital delay for a delayed channel: Connected to the Gymnasium speakers.
3. Gymnasium: Two loudspeakers, one located on each side of the moveable partition, shall provide directional realism of reinforced sound.
 - a. One-third octave equalization shall maximize the system's gain before feedback and provide overall smooth response.
 - b. Compressor/limiter shall protect loudspeaker components.
 - c. Digital delay feed from the Cafeteria shall allow user-selected, time-synchronized operation of the Gymnasium speakers when the partition is opened.

E. Miscellaneous equipment

1. Equipment rack
 - a. Welded assembly, 16g CRS, wall mounted equipment rack with front locking door.
 - b. Equal to Soundolier 300-28.
2. Microphone connectors (in-line and chassis mount)
 - a. Provide Cannon "XLR" type connectors or equal, quantity as required to provide complete system.
3. Microphone and line level wiring in conduit:

- a. Cable shall be equal to West Penn No. 292, one pair stranded, shielded No. 20 AWG with PVC jacket.
- 4. Loudspeaker cable in conduit:
 - a. Loudspeaker cable shall be equal to West Penn No. 226, one pair stranded No. 14 AWG with PVC jacket.
- 5. Provide a rack-mounted dual-well cassette deck with play and record functions available on each wall in the Cafeteria system.
 - a. Cassette deck shall be equal to Technics RSTR575
- 6. Provide a rack-mounted multidisk CD (compact disk) player in the Cafeteria system.
 - a. CD player shall be equal to Technics or Sony models.
- 7. Install two 8-inch by 11-inch computer-drawn system block diagrams on the equipment rack. One drawing will provide a graphic layout of the system with microphone, projector/aux inputs and CATV outlet positions identified. The other drawing shall provide a block diagram of the system's internal configuration. These drawings shall be installed behind a protective plastic laminate cover and permanently attached to the equipment rack.
- F. Hearing assistance system: Provide in the Cafeteria, connected to the output of the Rauland 4812 amplifier.
 - 1. FM hearing assistance system, installed in the Cafeteria sound cabinet and in a Soundolier 300-27 wall-mounted steel cabinet with locking front door.
 - a. Amplifier: Equal to Altec 1415A, 150 watts, with a high-pass filter connected to the output of the 4812 amplifier.
 - b. Components installed in wall-mounted cabinet: Hearing assistance amplifiers, processors, digital time delays, and other items.
 - 2. Receivers: Capable of receiving amplitude-modulated, inductive signals, using a 9-V battery as power source, with a 0.125-inch combination earphone and power charging jack on the top panel; equal to Williams Sound PWL-LR1. Provide 4 per system, complete with earbud, cord, and battery.
 - a. Enclosure: High-impact plastic case, nominally 3.5 inches high, 2.5 inches wide, and 0.75 inch deep, with top-mounted volume and power control and an LED On indicator.

2.4 INSTRUMENTAL AND GENERAL MUSIC ROOM SOUND SYSTEMS

- A. System of 2 wall-mounted loudspeakers per room, with cabling and jacks for connection of Owner's portable music systems.
- B. Loudspeakers: Equal to Electro-Voice Model EVID 6.2, with integrated tilt and angle wall brackets.
- C. Cables: 14-gauge West Penn No. 226/25226.

- D. Jacks: Color-coded, spring-loaded, push-to-open type, mounted on a single-gang, stainless-steel face plate.

2.5 SURGE PROTECTION

- A. Provide transient surge protection devices on the power feeds for each major component of equipment. This shall include equipment with CPUs, amplifiers, and similar devices. Surge protection devices shall be UL listed, equal to Transtector or Isobar. The devices shall have a 5 nanosecond or less response time for clipping excessive voltage. The surge protection devices shall consist of solid state circuitry, shall automatically reset after an operation with no degradation in protective capability, and shall have an indicating light to indicate when the unit is non-operational. Devices shall be direct plug-in type, plug strip type, or hard-wired connection type as applicable to the respective component of equipment.

2.6 CABLES

- A. The following cable shall be installed, according to the sound system manufacturer's recommendations in plenum applications:
 - 1. Cable for remote sound systems for priority control shall be one West Penn No. CL2-372 for non-plenum use (one pair plus one conductor shielded plus one pair unshielded 20 AWG with CL2P jacket).
 - 2. Cable for speakers in corridors, Cafeteria, Gymnasium and other areas without call-in shall be West Penn No. CL2-224, (two conductors 18 AWG with CL2P jacket).
 - 3. Microphone cable shall be West Penn No. CL2-292, (one pair shielded 20 AWG with CL2P jacket) or CL2-292.
 - 4. Telephone cable to be used in all areas shall be Standard Category 5E 4-pr 24 AWG twisted station cable for non-plenum applications with yellow colored jacket.
 - 5. Cable for classroom and individual loudspeakers shall be West Penn No. 358, 4-conductor, 20 AWG stranded with 22 AWG stranded drain wire, and overall PVC jacket for non-plenum applications.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions: Examine conditions under which telecommunications cabling and equipment and related components are to be installed in coordination with Installer of materials and components specified in this Section and notify affected Prime Contractors and Design consultant in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected to ensure a safe and timely installation.
 - 1. When Installer confirms conditions as acceptable to ensure proper and timely installation and to ensure requirements for applicable warranty or guarantee can be satisfied, submit to Design consultant written confirmation from applicable Installer. Failure to submit written confirmation and subsequent installation will be assumed to indicate conditions are acceptable to Installer.
 - 2. Visit Site to identify and become familiar with existing field conditions and specific requirements of each Site.
 - 3. Verify all dimensions in field and confirm condition of existing hardware to be utilized.
 - 4. Confirm space requirements and physical confines of all work areas to ensure that all materials can be installed in indicated spaces.

5. Confirm all device locations and cable pathways and advise Design consultant in writing of any discrepancies or issues in Design described in Contract Documents.

3.2 PREPARATION

- A. Protection: Provide adequate protection of equipment and hardware before and after installation.
- B. Existing Communications Services: Ensure all telecommunications systems (voice, video and data) remain operational throughout the project.
 1. Identify any additional intercom equipment, devices, and wiring at the site not shown on T-Drawings and interfering with installation of specified equipment.
 2. Remove all accessible portions of abandoned communications cabling per NEC 800.52. Tag all communications cabling not terminated at both ends but retained for future use.

3.3 INSTALLATION

- A. Provide and install all components necessary to install complete intercom/PA/master clock system, including (but is not limited to) cable, connectors, patch panels, call switches, speakers, etc.
- B. Secure all horizontal cables within ceiling cavities to building structure.
 1. Loosely bundle all cables and support from structure at unequal intervals from 5 to 6 feet with spring steel fasteners and cable clip rated for use with high performance cables (similar to Caddy Series "CableCat" or approved alternate mounting methods) including placement in cable tray as indicated on Drawings. All mounting clips shall be seismic type as per BOCA.
 2. Do not violate manufacturer's recommended loadings. Leave 30% capacity for future use of pathway.
 3. Verify all horizontal cable run lengths prior to installation. Re-distribute horizontal cabling to maintain distance requirements and maintain pathway route accessibility.
 4. Do not support cables from ceiling grid T-Bars, grid wire supports or bridle rings.
 5. Do not allow cables to touch ceiling grid.
 6. Install cables in EMT conduit in all unfinished, exposed areas as shown in Design consultant roof plans and/or T-Drawings, unless alternate pathways are noted.
 7. Do not secure cables with permanent cable ties. Do not tighten cable bundles in such a way as to cause jacket deformation or damage.
 8. Place cables in compliance with TIA/EIA-568.B standards and BICSI recommended methods.
 9. Re-terminate and re-test any cables or pairs of cables failing end-to-end testing requirements. Replace any faulty cables/pairs or termination devices. Remove all defective cables completely from pathways.
- C. Install all exposed cabling in surface raceway by Wiremold, Hubbell or Panduit where in-wall conduit has not been provided. Follow all manufacturers' guidelines requirements regarding bending radius and slack. All bends, offsets and fittings shall be appropriately sized to provide 30% capacity after installation.
- D. Install all cable in accordance with National, state and local codes and TIA/EIA Standards, and BICSI methods.
 1. Follow manufacturer's guidelines and requirements for all cable termination.

2. Follow detail drawings to locate equipment racks and cabinets. Where it is necessary to deviate, to obtain 30-inch clearance between equipment, obtain Design consultant's written approval before mounting cabinet/rack.
3. Ladder-type cable tray shall be affixed 6 inches above all data racks and equipment cabinets, and routed to all points of entry into each telecommunications room.
 - a. Include transition to proper height for penetration into hallway or other wall penetration as indicated on Drawings.
 - b. Install sufficient 4-inch conduits from telecom rooms into hallway (minimum of 2) with protective insulating bushings, cable spillway or specially designed cable tray sections, with appropriate firestop materials.
- E. Properly terminate all cables at speakers, call switches, administrative consoles and distribution racks. Permanently identify all cables in pullboxes, transition points, and termination points by affixing pre-marked self-adhesive wraps similar to Brady "B-500+ Plastic Cloth Markers."
- F. Permanently identify all system components following TIA/EIA-606A "Administration Standard for Commercial Telecommunications Infrastructure" with identification format:
 1. Identification: Provide permanent identification labels for end devices and associated cabling at each end.
- G. Intercom System
 1. Upon completion of work, all parts of the intercom/master clock installation shall be tested by the Contractor and demonstrated free of any defects. Preliminary testing will be permitted but shall not be accepted in lieu of obtaining final test results. Final test results shall be accomplished by the use of proper test equipment for the system being tested.
 2. Re-terminate and re-test any cables failing end-to-end testing requirements. Replace any faulty cables/pairs or termination devices. Remove all defective cables completely from pathways.
 3. Sound levels shall be balanced and demonstrated to be functioning properly.
 4. Accurate as-built drawings shall be provided in electronic and hard copy format.
 - a. 1 copy of electronic (CAD) drawings shall be distributed on disk.
 - b. 3 hard copies of CAD drawings shall be plotted on full size sheets and test results of every installed cable have been given to the construction management for appropriate distribution.

3.4 ACCEPTANCE

- A. Contractors work shall be considered complete after the following conditions have been met:
 1. Intercom installation is complete and all cable, devices and control equipment has been tested and documented to be installed according to specifications and drawings.
 2. A school district Technology representative has successfully tested the "LIVE" system.
 3. All punch list items have been reconciled.
 4. All disturbed ceiling panels, covers, etc. have been properly reinstalled.
 5. All materials and trash have been removed from the site.
 6. A 1-Year Installers warranty has been given to a school district Technology representative.
 7. Submit Manufacturers Extended Warranty Application.

END OF SECTION 275116

SECTION 275124 - INTERCOMMUNICATION EQUIPMENT FOR RESCUE ASSISTANCE

PART 1 - GENERAL

1.1 SUMMARY

- A. This section includes directly connected, manually switched, voice intercommunication equipment independent of telephone equipment, dedicated to communication with elevator lobbies.

1.2 SUBMITTALS

- A. Product data: Each component of the system.
- B. Shop drawings:
 - 1. Wiring diagrams: Power, signal, and control wiring. Include the following:
 - a. Identify terminals to facilitate installation, operation, and maintenance.
 - b. Single-line diagram showing interconnection of components.
 - c. Cabling diagram showing cable routing.

1.3 QUALITY ASSURANCE

- A. The hands-free station and its main console shall meet the requirements for "Areas of Rescue Assistance" mandated by the Americans with Disabilities Act (ADA).
- B. Installer qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this project.
 - 1. Maintenance proximity: In the Baltimore-Washington, DC metropolitan area.
- C. Electrical components, devices, and accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with NFPA 70.
- E. Comply with UL 50.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Talk-A-Phone.

2.2 FUNCTIONAL DESCRIPTION OF SYSTEM

- A. System designed for communication between elevator lobbies (EL) and a central location.
- B. Hands-free telephone station in the EL is designed for operation by and communication with people with disabilities including blindness and deafness.

- C. Main console communicates with more than one telephone station, includes audible and visual notification and station identification, and provides voice communication.

2.3 MAIN CONSOLE

- A. Talk-A-Phone CU-8R wall-mounted cabinet containing displays and telephone, and notification device mounted to standard 4-inch box.
- B. Cabinet: Flush-mounted, stainless steel, no less than 16 gauge, approximately 25 by 19 inches and 4.5 inches deep, with acrylic windows.
 - 1. Windows permit users to see telephone and operating instructions, and the LED display indicating active sites and sites in queue for response.
 - 2. Finish: No. 4.
- C. Communications: On the bottom, 8 RJ11 telephone ports for connection to the telephone stations; on the top, 3 RJ11 ports designated for telephone line in, telephone line out, and local line.
- D. Display: Separate LED display for each of the 4 telephone stations, power indication, and telephone line status indication.
- E. Notification device: Combination siren and strobe unit including relays and power supply.
 - 1. Siren: 8 sound options and 2 sound levels with range from 90 to 100 dBA, selected by user; automatically sounds when a call is received and shuts off when call is answered.
 - 2. Strobe: No less than 1 candela, flashing once per second; automatically flashes when a call is received and for the duration of the call.
- F. Telephone: Lighted telephone with 12-key pad.

2.4 HANDS-FREE TELEPHONE STATION

- A. Talk-A-Phone ETP-100EB recessed wall-mounted, vandal-resistant, pushbutton-operated emergency telephone.
- B. Cabinet: Flush-mounted, stainless steel, no less than 12-gauge face plate with grille, size to fit standard elevator telephone box (4-13/16 by 8-13/16, by 2-1/2). Finish: No. 4.
- C. Communications: Powered by telephone line from main console. Push button once to call, talk hands free.
 - 1. Autodialer calls a second number if the first number does not answer or is busy.
 - 2. Signal identifies the calling station at the main console.
 - 3. LED indicator and cast-metal raised letter and Braille signage.
- D. Accessories: Include tamperproof mounting devices.

2.5 CONDUCTORS AND CABLES

- A. Conductors: Jacketed, twisted pair and twisted multipair, untinned solid copper. Sizes as recommended by system manufacturer, but not smaller than No. 22 AWG.

- B. Wiring between hands-free telephone stations and main console shall not exceed resistance of 25 ohms.
 - 1. Minimum shielding coverage on conductors: 60 percent.
- C. Plenum cable: Listed and labeled for plenum installation.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Wiring method: Install wiring in raceways except within consoles, desks, and counters. Conceal cables and raceways except in unfinished spaces.
- B. Wiring within enclosures: Bundle, lace, and train conductors to terminal points with no excess. Use lacing bars in cabinets.
- C. Control-circuit wiring: Install number and size of conductors as recommended by system manufacturer for control functions indicated.
- D. Separation of wires: Separate intercommunication equipment conductors as recommended by equipment manufacturer.
- E. Connect wiring according to Section 260521.

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. Engage a factory-authorized service representative to perform startup service.
- C. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
- D. Complete installation and startup checks according to manufacturer's written instructions.

3.3 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain intercommunication equipment.

END OF SECTION 275124

SECTION 280101 - ELECTRONIC SAFETY AND SECURITY GENERAL PROVISIONS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. General provisions and requirements for electronic safety and security work.

1.14 RELATED SECTIONS

- A. Requirements of this section generally supplement requirements of Division 01.
- B. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.

1.20 REFERENCES

- A. NFPA 10: Portable Fire Extinguishers.
- B. NFPA 241: Safeguarding Construction, Alteration, and Demolition Operations.

1.24 SYSTEM DESCRIPTION

- A. The full set of Contract Documents applies to work of Division 28.
- B. Visit the site and study all aspects of the project and working conditions, as required by General and Supplementary Conditions, Bidding and Contracting Requirements, Drawings, and Specifications. Verify field dimensions.
- C. The work covered in technical sections includes the furnishing of all labor, equipment and materials, and the performance of all operations pertinent to the work described.
- D. Except as required otherwise in Division 01, promptly obtain and pay for, all necessary signatures and paperwork, all permits, fees and inspections required for work of this division by authorities having jurisdiction, including any utility connection or extension charge. No payment will be made until a copy of the permit is forwarded to the Owner.
- E. Electronic safety and security work of this project includes, as a brief general description, the following:
 - 1. Fire detection and alarm system.
 - 2. Access control.
 - 3. CCTV.
 - 4. Intrusion detection,
 - 5. The project includes commissioning under the direction of a Commissioning Agent (CxA).
 - 6. The project will be LEED certified.
- F. See Division 01 for requirements related to LEED certification, commissioning, limits on use of site, time restrictions on work, limits on utility outages or shutdowns, and phasing (sequencing) and scheduling.

1.26 PRODUCT OPTIONS

- A. Except as modified by provisions of Bidding and Contracting Requirements and Division 01, these options apply to Division 28 specifications.
- B. General: Where Contractor is permitted to use a product other than the specified item and model named as the basis of design, Contractor is responsible for all coordination and additional costs as specified in article "Substitutions" below for substitutions.
- C. Products specified by reference standards or by description only: Any product meeting those standards or description.
- D. Products specified by naming one or more manufacturers, or model name or catalog reference number: Products specified establish a standard of quality, options to be included, and performance.
 - 1. Where other acceptable manufacturers are named, Contractor may provide products of those named manufacturers only, which meet the specifications.
 - 2. Where specification permits "equal" products, without naming other acceptable manufacturers, Contractor may use products of any manufacturer, which meet the specifications.
- E. Products specified by naming one manufacturer and particular product, with no provision for other options: No options or substitutions allowed.

1.27 SUBSTITUTIONS

- A. Substitutions will be considered only as permitted or required by the Bidding and Contracting Requirements and Division 01. Except as modified by those requirements, the requirements below apply to Division 28 specifications.
- B. Substitutions may be considered when a product becomes unavailable through no fault of the Contractor.
- C. Document each request with complete data substantiating compliance of proposed substitution with contract documents.
- D. A request constitutes a representation that the Bidder or Contractor:
 - 1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product.
 - 2. Will provide the same warranty for the substitution as for the specified product.
 - 3. Will coordinate installation and make changes to other work which may be required for the work to be complete with no additional cost to Owner.
 - 4. Waives claims for additional costs or time extension which may subsequently become apparent.
 - 5. Will reimburse Owner for review or redesign services associated with re-approval by authorities.
- E. Substitutions will not be considered when they are indicated or implied on shop drawing or product data submittals, without separate written request, or when acceptance will require revision to the Contract Documents.

- F. Substitution submittal procedure is specified in Bidding and Contracting Requirements and Division 01.

1.28 MATERIALS AND EQUIPMENT

- A. All materials and equipment shall be new and the best of their respective kinds, suitable for the conditions and duties imposed on them by the project and of representative manufacturer. The description, characteristics and requirements of the materials to be used shall be in accordance with the specifications.
- B. All equipment, construction and installation must meet requirements of local, state and federal governing codes.
- C. Singular number: In cases where material, a device, or part of the equipment is referred to in the singular number in the specifications, it is intended that such reference shall apply to as many items of material, devices, or parts of the equipment as are required to complete the installation as shown on the drawings or required for proper operation of the system.
- D. Terms have the following meanings:
 - 1. Furnish: Supply item
 - 2. Install: Mount and connect item
 - 3. Provide: Furnish and install
- E. All materials and equipment shall be installed and completed in a first class and workmanlike manner and in accordance with the best modern methods, practice and manufacturer's instructions. Any work which shall not present an orderly and neat or workmanlike appearance shall be removed and replaced with satisfactory work when so directed in writing by the Architect.
- F. The specifications and drawings are intended to define the minimum requirements, as to quality of materials, construction, finish and overall workmanship.
- G. General Conditions describe the correlation and intent of the Contract Documents. In case of discrepancies between the specifications and drawings, the specifications should be followed as to the general methods and principles and the drawings followed as to sizes, capacities and specifics for corresponding parts. If sizes are omitted, the Architect will determine sizes to be utilized.
- H. In all cases of doubt, uncertainty, or conflict as to the true meaning of the specifications or drawings, it is the responsibility of the Contractor to notify the Architect of said uncertainty, doubt, or conflict and obtain a decision as to the intent prior to initiating any work which may be affected by this decision.

1.29 COORDINATION

- A. Should a situation develop during construction to prevent the proper installation of any equipment or item where shown on the drawings, call the situation to the attention of the Architect and await a written decision.
- B. Plan and coordinate all work to proceed in an orderly and continuous manner without undue delay, and in conformance with the project schedule. Submit samples, shop drawings, schedules, insurance policies and certificates, and the like in time to avoid delays in actual construction. Coordinate electronic safety and security work so that work of each trade is completed before other construction begins which would obstruct it.

- C. Coordinate trades to ensure that proper clearances between work of the various trades allow access to items which require operation and maintenance.
- D. Coordinate location and elevation of all conduit, light fixtures, equipment, and appurtenances in such a manner that the finished installation is as indicated on drawings. In the event difficulties are encountered which prevent this, it is the Contractor's responsibility to bring this to the attention of the Architect prior to initiation of work. Correct improperly coordinated installation at no additional cost.
- E. The Contractor's assistants shall include a competent electronic safety and security foreman, who shall be on the premises at all times to check, lay out, coordinate and superintend the installation of work. The foreman shall establish all basic requirements relative to the work before starting, and be responsible for the accuracy thereof.

1.30 SUBMITTALS

A. Manufacturers' and subcontractors' lists:

1. As specified in Division 01, submit a complete list of proposed manufacturers for all equipment, materials and subcontractors used for the work of this division. Lists shall follow the sequence of the specifications. No considerations will be given for partial or incomplete lists. After review of lists, submit shop drawings and product data.

B. Shop drawings and product data:

1. Submit in accordance with the requirements of Division 01 or as established at the preconstruction conference, the required number of copies of Shop Drawings and Product Data for every item of equipment. Shop drawings or product data will not be considered until Manufacturers' Lists have been approved. Shop drawings and product data shall be submitted, as required by the General Conditions, with sufficient time for checking, return to Contractor, and resubmission as required before Contractor shall install any item.
2. Each item submitted shall be properly labeled, indicating the specific service for which the equipment or material is to be used, section and paragraph number of specification or drawing number to which it applies, Contractor's name and project name and number. Data submitted shall be specific and shall include product data and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents. Clearly identify each item within the data. Data of a general nature will not be accepted. Each sheet must clearly show the project name and number.
3. The review of a shop drawing or product data shall not be considered as a guarantee of the measurements or building conditions or that the shop drawings or product data have been checked to see that item submitted properly fits the building conditions. This review shall not relieve the Contractor of the responsibility for furnishing material or performing work as required by the contract documents, for correctness of dimensions and quantities, or for proper coordination of details and interfaces among trades.
4. All exclusively electronic safety and security items furnished as items associated with mechanical items but not specifically described in the mechanical item submission, shall be submitted as a separate submittal but shall be clearly marked as associated with the mechanical item by identified specification paragraph.
5. Product data sheets shall be 8.5-inches by 11-inches cut sheets for operating and maintenance manual.

- C. Submit at least three copies of the results of every test required under any section in this division.

- D. Specialist shall submit a list of at least three projects similar to this project in type, size, and quality, which have been in place and operating satisfactorily for at least five years.
 - 1. Include project name, address, name and phone number of owner's representative, and project type and size.
- E. After the work is completed, submit all required certificates of approval from approved inspection agencies and authorities having jurisdiction over work of this division. Certificates of approval must be received by the Architect prior to final acceptance of the work.

1.34 SPECIALIST

- A. The term "Specialist" as used in the specification shall mean an individual or firm of established reputation (or, if newly organized, whose personnel have previously established a reputation in the same field,) which is regularly engaged in, and which maintains a regular force of workers skilled in either (as applicable) manufacturing or fabricating items required by the contract, installing items required by the contract, or otherwise performing work required by the contract. Where the specification requires installation by a specialist, the term shall also be deemed to mean the manufacturer of the item, an individual or firm licensed by the manufacturer, or an individual or firm who will perform the work under the manufacturer's direct supervision.

1.35 CONTRACT CLOSEOUT SUBMITTALS

A. Project record documents:

- 1. Maintain on site one set of the following record documents; record actual revisions to the work of this division:
 - a. Contract Drawings.
 - b. Specifications.
 - c. Addenda.
 - d. Change Orders and other Modifications to the Contract.
 - e. Reviewed shop drawings, product data, and samples.
- 2. Maintain record documents separate from documents used for construction.
- 3. Record information concurrent with construction progress.
- 4. Specifications: Legibly mark and record in each section a description of actual products installed, including the following:
 - a. Manufacturer's name and product model and number.
 - b. Product options, substitutions, or alternates utilized.
 - c. Changes made by addenda and modifications.
- 5. Record documents and shop drawings: Legibly mark each item to record actual construction, including:
 - a. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the work.
 - b. Field changes of dimension and detail.
 - c. Details not on original Contract Drawings.
- 6. Submit documents as specified in Division 01.

B. Operation and maintenance data:

1. Submit sets prior to final inspection as specified in Division 01. Unless otherwise specified in Division 01, submit no fewer than three sets. In addition to requirements specified in Division 01, submit operating and maintenance manuals for the work of this division as specified below.
2. Binders: Provide large enough binders, and sufficient quantity, that the required contents can be easily turned, removed, and reinserted.
 - a. Self-expanding fast lock type.
 - b. Three telescoping metal posts.
 - c. Durable plastic covers.
 - d. Angle spline with guide flanges.
 - e. Text page size - 8.5 by 11 inches.
 - f. Boorum and Pease, Stock No. C-619-3 expansion 3 inch to 5 inch or Stock No. C-1219 expansion 1.5 inch to 2.5 inch, or equal by National or Wilson Jones.
3. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS", and title of project. Print on spine of binder "O & M INSTRUCTIONS." If more than one binder is required, print covers and spines with volume numbers. Include in the front of every binder an index to all binders.
4. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.
5. Contents: Prepare a Table of Contents for each volume, with each product or system description identified, typed on white paper.
6. Part 1: Directory, listing names, addresses, and telephone numbers of engineers; contractor; electronic safety and security subcontractors; and major electronic safety and security equipment suppliers.
7. Part 2: Operation and maintenance instructions, arranged by specification section. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers. Identify the following:
 - a. Significant design criteria.
 - b. List of equipment.
 - c. Parts list for each component, including recommended spare parts list.
 - d. Operating instructions.
 - e. Maintenance instructions for equipment and systems.
 - f. Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.
8. Part 3: Project documents and certificates, including the following:
 - a. Shop drawings and product data.
 - b. Photocopies of certificates.
 - c. Photocopies of warranties, guarantees, and bonds.
 - d. Test reports: Copies of the results of all tests required under all sections of specifications.
9. Submit one copy of completed volumes in final form 15 days prior to final inspection. This copy will be returned after final inspection, with Engineer comments. Revise content of documents as required prior to final submittal.
10. Submit final volumes revised, within ten days after final inspection.
11. Submit DVD optical disc storage media specified in Section 280500.

1.42 REGULATORY REQUIREMENTS

- A. When these specifications call for materials or construction of a better quality or larger sizes than required by the following codes and standards, the provisions of the specifications shall take precedence.
- B. Provide, without extra charge, any additional materials and labor which may be required for compliance with these codes and standards even though the work is not mentioned in these specifications or shown on the contract drawings.
- C. Perform the work of this division in strict accordance with the following authorities. The latest revision of these codes accepted by the authority having jurisdiction as of the date of the contract documents shall apply.
 - 1. The electrical, building, fire, and safety codes of the state and county or city in which the work is being performed.
 - 2. The National Electric Code, NFPA 70 (NEC).
 - 3. The National Fire Protection Association Code. (NFPA)
 - 4. International Building Code (IBC).
 - 5. International Energy Conservation, Fire, and Electrical Codes (ICC).

1.43 REFERENCE STANDARDS

- A. Perform the work of this division using the standards of the following organizations, as referred to in technical sections, as a minimum requirement for construction and testing. Unless specified otherwise in Bidding and Contract Documents or Division 01, the latest revision current as of the date of the contract documents shall apply.
 - 1. Federal Specifications (FS)
 - 2. Military Specification (MS)
 - 3. Military Standards (Mil. Std.)
 - 4. American National Standards Institute (ANSI)
 - 5. American Society for Testing and Materials (ASTM)
 - 6. International Code Council (ICC)
 - 7. Institute of Electrical and Electronics Engineers (IEEE)
 - 8. National Electrical Code (NEC) (NFPA 70)
 - 9. National Electrical Manufacturer's Association (NEMA)
 - 10. National Fire Protection Association (NFPA)
 - 11. The Occupational Safety and Health Act (OSHA)
 - 12. Underwriters Laboratory Inc. (UL)
 - 13. Maryland Occupational Safety and Health Act (MOSHA)

1.53 TEMPORARY STORAGE

- A. Maintain upon premises, where directed, a storage area, and be responsible for all contents within these areas. Provide all security measures necessary for this area.
- B. Area shall be maintained and shall be returned to original condition at the completion of the project.
- C. Store electronic safety and security construction materials such as wire, raceways and boxes, devices, and equipment in buildings, enclosed trailers, or portable enclosed warehouses.
 - 1. Materials and products subject to damage from moisture: Store in dry locations. If necessary, protect with protective wraps or covers.

2. Plastics and other materials and products subject to damage from heat or cold: Store at manufacturer's recommended temperatures.
 3. Plastics and other materials and products subject to damage from sunlight: Protect from sunlight.
- D. Electronic safety and security equipment stored before installation and installed during construction: Provide clean, dry locations at manufacturer's recommended temperatures, and cover or wrap if required to protect from incidental damage.

1.54 PROTECTION

- A. Each trade and subcontractor is responsible for preventing damage and soiling of work performed by other trades or subcontractors. Each trade and subcontractor is responsible for providing temporary protection of its own work.
1. Protect work from spills, splatters, drippings, adhesives, bitumens, mortars, paints, plasters, and damage from welding or burning.
 2. Protect finished work from damage, defacement, staining, or scratching.
 3. Protect finishes from cleaning agents, or grinding and finishing equipment.
 4. Protect adjacent and finished work from damage, using tape, masking, covers or coatings and protective enclosures.
 5. Coordinate installations and temporarily remove items to avoid damage from finishing work.
- B. Repair all damage or soiling to the complete satisfaction of the Architect; replace any materials or work damaged to such an extent that they cannot be restored to their original condition, all at no addition to the Contract sum.
- C. Protect work stored in place and supplies stored in the building.
1. Store materials and products, subject to damage from moisture, in dry locations. If necessary, protect in wraps or covers.
 2. Store plastics, other materials, and products subject to damage from heat or cold at manufacturer's recommended temperatures.
- D. Protect electronic safety and security materials and products from weather events and accidents of construction.
- E. Use of sidewalk or roadway areas outside of the property lines shall be with permission and approval of the local authorities having jurisdiction.

1.55 FIRE PROTECTION

- A. As a minimum, provide hand-carried, portable, UL-rated extinguishers with each work crew working inside the building.
- B. Select extinguishers in accordance with NFPA 10 and NFPA 241 for classification, extinguishing agent, and size required by location and class of fire exposure.

1.60 PROJECT CONDITIONS

- A. Drawings showing utilities in concealed locations are based on the best information available but are not represented as being precisely correct. Work of the contract includes digging, cutting, drilling, using nondestructive methods, and other methods of locating concealed utilities in the field, as well as patching and repairing as specified in "Cutting and Patching" below.
- B. If, in the course of the work, workers encounter a material they suspect to present some hazard:
 - 1. Promptly notify the Architect in writing.
 - 2. Do not perform any work which would disturb the suspected material until written instructions have been received.

1.80 WARRANTY

- A. All work and equipment provided as work of this division shall be fully warranted under the general project warranty. In addition, provide added special warranties as specified in individual sections.
- B. During the correction period, the Contractor shall promptly correct any work found to be defective or otherwise not in accordance with the requirements of the Contract Documents, on receipt of written notice from the Owner. Except as otherwise required in General Conditions and Division 01, the correction period is two years after the date of substantial completion of the work. Work requiring correction shall promptly be repaired or completely replaced at no addition to the Contract Sum.
- C. When use of the permanent equipment has been permitted for temporary services during construction of the building, the warranty and correction periods shall nevertheless begin at the time of substantial completion, unless another date of acceptance has been agreed to by the Owner.
- D. Special warranties are warranties required by individual specification sections, incidental product warranties, manufacturers' standard warranties, installer or subcontractor service agreements, and other individual warranties in addition to the general project warranty.
- E. Provide copies of warranties as required for Operation and Maintenance Manual specified above, and by Division 01.
- F. For items of work delayed beyond date of substantial completion, provide updated submittal within ten days after acceptance, listing date of acceptance as start of warranty period.

1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractors' and subcontractors' responsibilities are described in Division 01.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.11 CUTTING AND PATCHING

- A. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
- B. Cut walls, floors, partitions, roofs, and other appurtenances for the passage or accommodation of raceways. Close superfluous openings and remove all debris caused by work of this division.
- C. No cutting of any structure or finish shall be done until the condition requiring such cutting has been examined and approved by the Architect.
- D. New or existing surfaces disturbed as a result of such cutting or otherwise damaged shall be restored to match original work and all materials used for any patching or mending shall conform to the class of materials originally installed.
- E. Refinish surfaces to match adjacent finish. For continuous surfaces, refinish to nearest intersection or natural break. For an assembly, refinish entire unit.

3.14 TEMPORARY FACILITIES

- A. Temporary water facilities, electricity, telephone, toilet facilities, and temporary heat, shall be provided as specified in Division 01.

3.40 PROGRESS MEETINGS

- A. Progress meetings shall be held as specified in Division 01, and also when and if the Contractor or Architect finds them necessary or advantageous to progress of work.
- B. Contractor, those subcontractors and those material suppliers concerned with current progress or with the scheduling of future progress, Architect and Owner shall each be represented at these meetings by persons familiar with the details of work and authorized to conclude matters relating to work progress.

3.82 COMMISSIONING

- A. Comply with requirements of "Commissioning" in Part 1 above.

END OF SECTION 280101

SECTION 280500 - COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Requirements applicable to work of more than one section of Division 28.
- B. Electronic Safety and Security identification.
- C. Testing wiring systems.

1.14 RELATED SECTIONS

- A. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.
- B. Operation and Maintenance Manuals: Division 01 and Section 280101.
- C. Painting: Division 09.

1.21 DEFINITIONS

- A. Project correction period: A period after Substantial Completion of the work during which the Contractor shall correct every part of the work found to be not in accordance with the requirements of the contract documents, promptly after receipt of written notice.
- B. Qualified testing agency: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ASTM E 548; and with additional qualifications specified in individual sections; and where required by authorities having jurisdiction, that is acceptable to authorities.
 - 1. NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7.
 - 2. NVLAP: A testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program.

1.26 DESIGN REQUIREMENTS

- A. The drawings and system performances have been designed on the basis of using the particular manufacturers' products specified and scheduled on the drawings.
- B. Products of other manufacturers that are listed under the article "Acceptable Manufacturers," or permitted as "equal," are permitted provided:
 - 1. Product shall meet the specifications.
 - 2. Contractor shall make, without addition to the contract sum, all adjustments for deviations so that the final installation is complete and functions as the design basis product is intended.
- C. Do not propose products with dimensions or other characteristics different from the design basis product that make their use impractical or cause functional fit, access, or connection problems.
- D. The contract drawings are generally diagrammatic, and do not indicate all fittings or offsets in conduit or all pull boxes, access panels, or other specialties required.

1. Install conduit exposed to view parallel with the lines of the building and as close to walls, columns, and ceilings as may be practical, maintaining adequate clearance for access at parts requiring servicing.
2. Install conduit a sufficient distance from other work to permit a clearance of not less than 0.5 inch (15 mm) between its finished covering and adjacent work.
3. No conduit shall be run below the head of a window or door.
4. Pull boxes and other appurtenances which require operation or maintenance shall be easily accessible. Do not cut or form handholes for operation or maintenance of appliances through walls or ceilings.

1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 280101.
- B. Test reports: Show that tests specified in Part 3 below demonstrate the specified results.
- C. LEED submittal:
 1. Product data for Indoor Environmental Quality (IEQ) Credit 4.1: For adhesives and sealants, include printed statement of VOC content.
 2. Product data for Indoor Environmental Quality (IEQ) Credit 4.4: For wood products such as plywood equipment backboards, include printed statement of non urea-formaldehyde component present in material.

1.40 QUALITY ASSURANCE

- A. Provide materials and perform work in accordance with the electrical, building, fire, and safety codes and regulations of the state, county, or city in which the work is performed.
- B. Electronic safety and security equipment, materials and devices provided or installed as work of Division 28 shall bear UL label, or, if UL label is not available, the item shall be tested and labeled by a qualified testing agency, acceptable to authorities having jurisdiction, and in accordance with NFPA 70. Provide testing, if required, without addition to the contract sum.
- C. Qualifications of DVD documentation technician: For video documentation specified in "Operating Instructions (Demonstration)," employ persons knowledgeable in DVD optical storage media format for video and audio production and editing.
- D. The project shall be LEED certified. See requirements specified in Division 01 and individual sections for LEED requirements, waste and air quality control.
- E. VOC content: Field-applied adhesives and sealants, limits per South Coast Air Quality Management District (SCAQMD), Rule No. 1168.
- F. Products shall contain no urea-formaldehyde content.

1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractors' and subcontractors' responsibilities are described in Division 01.

PART 2 - PRODUCTS

2.10 MATERIALS

- A. Electronic equipment backing panels: Plywood, DOC PS 1, Exposure 1, C-D Plugged, fire-retardant treated in accordance with AWPA C27, in thickness indicated, not less than 0.5 inch (13 mm) nominal.
 - 1. One side finished.
- B. Wood-preserved-treated lumber: Treated by pressure process, AWPA C2, with chemicals acceptable to authorities having jurisdiction, and marked with treatment quality mark of an inspection agency approved by the ALSC Board of Review.
 - 1. Application: Treat items indicated on the drawings, and the following:
 - a. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, or waterproofing.
 - b. Wood sills, sleepers, blocking, and similar concealed members in contact with masonry or concrete.
 - c. Wood framing and furring attached directly to the interior of below-grade exterior masonry or concrete walls.
 - d. Wood framing members that are less than 18 inches (460 mm) above the ground in crawlspaces or unexcavated areas.
 - e. Wood floor plates that are installed over concrete slabs-on-grade.
- C. Nameplates: Laminated plastic, engraved, white letters on black background, except where other colors are noted or specified.
 - 1. Size: Minimum 0.75 inch (19 mm) by 2.5 inches (64 mm).
 - 2. Letter size: Minimum height 0.1875 inch (5 mm).
 - 3. Fasteners: Vandalproof brass screws or rivets.
- D. Aircraft cable: 0.25-inch (6-mm) steel wire rope, galvanized, construction 7 by 19 strands, minimum 7000 lbs (31138 N) breaking strength.

2.21 DATE-SENSITIVE EQUIPMENT

- A. Date-sensitive equipment: Systems, equipment, or components which use or process date and time data in order to perform their functions.
- B. Each item of date-sensitive equipment used in the project shall be warranted by the manufacturer to properly function and correctly use or process all time-related data for all dates and times which occur during a reasonable life expectancy of the equipment.

PART 3 - EXECUTION

3.03 INSTALLATION OF PRODUCTS AND EQUIPMENT

- A. Manufacturers' instructions: Except as modified by drawings or specifications, install products and equipment in accordance with manufacturers' instructions and recommendations applicable to the project conditions.

1. Immediately notify Architect if a difference or discrepancy is found between manufacturers' instructions and the drawings or specifications.

B. Install plywood backing panels with finished face exposed.

3.59 IDENTIFICATION

A. Items to be identified include, but are not limited to:

1. Control devices.
2. Cables.
3. Control panels.
4. Equipment
5. Other appurtenances.

B. Identify function, equipment served, and area served.

3.61 TESTS

A. During the progress of the work and after completion, test the circuits, and electronic safety and security system, and the low voltage alarm and signal systems.

B. Results of the tests shall show that the wiring meets the requirements of this specification. Should any test indicate defect in materials or workmanship, immediately repair, or replace with new, the faulty installation, and retest the affected portions of the work.

C. Furnish equipment and instruments necessary for testing.

D. Tests shall demonstrate the following:

1. Power, control, and system circuits are continuous and free from short circuits.
2. Circuits are free from unspecified grounds.
3. The resistance to ground of each non-grounded circuit is not less than one megohm.
4. Circuits are properly connected in accordance with the applicable wiring diagrams.
5. Circuits are operable.

E. Immediately repair defects and retest until systems are operating correctly.

F. Submit test reports.

3.81 OPERATING INSTRUCTIONS

A. Furnish the necessary technicians, skilled workers, and helpers to operate the electronic safety and security systems and equipment of the entire project for one 8-hour day.

B. Where specified in technical sections, provide longer periods required for specialized equipment.

C. Instruct the Owner or designated personnel in operation, and adjustment of systems and equipment.

D. The Operating and Maintenance Manual shall be available at the time of the instructions for use by instructors and Owner personnel.

- E. Record each instruction session only in DVD media format (video and audio format), including both the sessions specified above and added sessions required in technical sections for specialized equipment. Provide one complete set of DVDs with each Operating and Maintenance Manual.
- F. Schedule the general and specialized instruction periods for a time agreed upon by the Owner and Architect.

END OF SECTION 280500

SECTION 281600 - INTRUSION DETECTION SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Intrusion detection cabling.
- B. Intrusion detection sensors.
- C. Intrusion detection end devices.
- D. Connection to and/or expansion of existing Intrusion Detection headend equipment.
- E. Associated power supplies, terminations, equipment, labeling and associated cable performance testing.

1.2 DEFINITIONS

- A. Intrusion Detection system refers to burglar alarm equipment including motion detectors, door contacts, control panels, communication panels, power supplies, expansion modules and associated wiring.

1.3 SYSTEM DESCRIPTION

A. Design Requirements:

- 1. Provide labor, materials, equipment, services and operations required for a complete installation an Intrusion Detection System.
 - a. Base panel – connect to and/or expand existing panel.
 - b. Expansion modules.
 - c. Keypads.
 - d. Annunciators – existing.
 - e. Motion detectors.
 - f. Door contacts.
 - g. Communication modules.
 - h. Power supplies.
- 2. All wiring shall be wired according to manufactures specifications.
 - a. Refer to notes on each drawing to determine exact installation methods.
 - b. Strictly adhere to most current version of TIA/EIA Telecommunications cabling standards.
 - c. Permanently identify and label all cables and termination devices, at distribution rack and workstation in accordance with ANSI TIA/EIA-606 Standard or as agreed by Design consultant and Authority.
 - d. Remove and replace any cables failing to meet end-to-end testing requirements; do not abandon cable in place. All cable shall be terminated at both ends, unless noted on drawings.

B. Performance Requirements:

- 1. The system shall produce a signal (both visual and audible) if the system is breached by an unauthorized user.

2. Each sensor shall be individually alarmed.
3. The system shall be capable of being scheduled.
4. The system shall be capable of being controlled from the main panel, keypad locations, central station and PC connected to the LAN.
5. The intrusion detection system will alert and record movement throughout the facility that is both authorized and unauthorized.
6. The systems will be capable of communicating onsite as well as to remote locations.
7. The systems shall be controllable in case of emergency situation.
8. All systems shall operate on dedicated circuits with associated cabling in EMT.
9. Comply with applicable requirements in Local, State and Federal Codes, TIA/EIA Standards, and BICSI methodology.
10. Specified cabling system derived from recommendations in approved telecommunications industry codes, standards and methods, including the following documents:
 - a. Articles 250, 725, 760, 770, 800,810 and 820 of the current National Electrical Code.
 - b. ANSI/TIA/EIA-568-B.1: Commercial Building Telecommunications Cabling Standard Part 1 – General Requirements
 - c. ANSI/TIA/EIA-568-B.2: Commercial Building Telecommunications Cabling Standard Part 2 – Balanced Twisted Pair Cabling Components and subsections.
 - d. ANSI/TIA/EIA-568-B.3: Commercial Building Telecommunications Cabling Standard Part 3 – Optical Fiber Cabling Components
 - e. ANSI/TIA/EIA-569-A: Commercial Building Standard for Telecommunications Pathways and Spaces
 - f. ANSI/TIA/EIA-606: Administration Standard for Telecommunications Infrastructure of Commercial Buildings
 - g. ANSI/TIA/EIA-607: Commercial Building Grounding and Bonding Requirements for Telecommunications
 - h. BICSI Telecommunications Distribution Methods Manual (TDMM), Tenth Edition
 - i. National Fire Protection Agency (NFPA-70): National Electrical Code (NEC)

1.4 SUBMITTALS

- A. Comply with requirements of Division 00 and Division 01 - Submittals and as modified below.
- B. Product Data: Submit manufacturer's product literature, technical specifications and similar information for the following items demonstrating compliance with the specified requirements.
 1. Motion Detectors and Door Contacts
 2. Headend Control Panels and Communications Modules, if required
 3. Power supplies
 4. Copper cable and termination devices.
 5. Wiring diagrams.
- C. Samples: Provide samples of assemblies and connections as described below, prior to installation, for approval by designer.
 1. Intrusion Detection cables and connections – Submit samples of cables and terminations to be provided including following components and characteristics:
 - a. Provide all components in colors selected by Architect.
- D. Quality Control Submittal:

1. Test Reports: Submit complete sample test data and reports with exact labels used on cables termination fields.
2. Certificates
 - a. Manufacturer Certification: Submit certification from manufacturer of products to be installed under this contract certifying that Installer is authorized by manufacturer to install specified products.
 - b. Installer Experience Listing: Submit list of at least 5 completed projects as specified below in "Quality Assurance – Qualifications – Installer."
- E. Contract Closeout Submittal: Comply with requirements of Division 00, including submission of operating and maintenance instructions as item in "Operation and Maintenance Data" manual described in that Section.

1.5 QUALITY ASSURANCE

- A. All Work shall be installed in a first class, neat and workmanlike manner by skilled Technicians. The quality of the workmanship shall be subject to inspection and approval by authorized school district personnel. Any work found to be of inferior quality and/or workmanship shall be replaced and/or reworked until the approval of school district personnel is obtained.

B. Qualifications

1. Installer:

- a. Installer shall be one of the following current BCPS on-call Security contractors:

- 1) ARK Systems, Inc.
9176 Red Branch Road
Columbia, MD 21045
Shari Coccia, Sales Manager
scoccia@arksysinc.com
410-997-0188
- 2) ASG Security, LLC
12301 Kiln Court, Suite A
Beltsville, MD 20705
Bruce Schraudner, Sr. Account Executive
bschraudner@asgsecurity.com
443-423-3870
- 3) Ingersoll Rand Security Technologies
6679M Santa Barbara Road
Elkridge, MD 21075
Tobe Henry, Senior Security Consultant
Tobe_Henry@irco.com
410-379-5078
- 4) Netcom Technologies, Inc.
7423 Lindbergh Drive
Gaithersburg, MD 20879
Stewart Gill, Director of Business Development
sgill@netcomtec.com
301-670-0486 x117

- b. Qualified to cable, terminate, program and test Intrusion Detection systems, and associated power wiring specified in this Section and other Division 17000 series specifications, certified by manufacturer of products to be installed, and completed at least 5 installations of similar size, nature and complexity as specified for this project.
- C. Conditions for Consideration of "Or Equal" Products: Where products are specified by name and accompanied by the term "or equal", the proposed "or equal" product will be considered when the following conditions are satisfied. If all the following conditions are not satisfied, Design Consultant will return requests without action, except to record noncompliance with these requirements:
 - 1. Proposed product does not require extensive revisions to the Contract Documents.
 - 2. With the exception of the product name or number and manufacturer's name, proposed product conforms with requirements indicated on the Drawings and in the Specifications in every respect and will produce indicated results.
 - 3. Proposed product is fully documented and properly submitted.
 - 4. Proposed product has received necessary approvals of authorities having jurisdiction.
 - 5. Proposed product is compatible with AND has been coordinated with other portions of the Work.
 - 6. Proposed product provides specified warranty.
 - 7. If proposed product involves more than one contractor, proposed product has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.
 - 8. Submission is accompanied with detailed comparison of significant qualities of proposed product with those named in the Specifications. Significant qualities include attributes such as performance, weight, size, durability, visual effect, and specific features and requirements indicated.
 - 9. Submission is accompanied with a list of similar installations for completed projects with project names and addresses and names and addresses of design consultants and authorities, if requested.
 - 10. Submission is accompanied with proposed product's Manufacturer signed written statement on Manufacturer's letterhead, certifying that manufacturer complies with requirements in the Contract Documents.

1.6 WARRANTY

- A. Installer's Warranty: Provide manufacturer's system warranty against electrical or mechanical defects for 2 year from date of final acceptance.
- B. Manufacturer warranty coverage for cable systems associated with the Intrusion Detection System and associated Access Control System

1.7 TRAINING

- A. Installing contractor shall provide a minimum of 4 hours of training on system operation and managements as part of their scope of work.
 - 1. Additional hours shall be provided on a time and materials basis at the request of the owner.
- B. Installing contractor shall provide a video recording on a standard format DVD to the owner which includes training sessions.

1.8 OPERATION AND MAINTENANCE MANUALS

- A. Installing contractor shall provide a minimum of two hardcopy and one electronic copy of all operation and maintenance manuals to the owner at project completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Manufacturers:

- 1. The Intrusion Detection System basis of design is Bosch System

2.2 MATERIALS

- A. Bosch D9412GV2 Intrusion and Access Panel: Existing to remain.

- B. Bosch D9412GV2 Accessories: Provide as required.

- 1. D110 Tamper Switch
 - 2. D101 Lock and Keyset
 - 3. D122 Dual Battery Harness
 - 4. D137 Mounting Bracket
 - 5. D928 Dual Phone Line Switcher
 - 6. D1238 Battery
 - 7. D1640 Transformer

- C. Bosch Remote Programming Software: Program as required.

- D. Bosch D8125 Addressable Zone Expander Module

- E. Bosch DX4010V2 USB Interface Module

- F. Bosch D113 Battery Lead Supervision Module

- G. Bosch D8230 Door Release Module

- H. Bosch D9127 Popit Module

- I. Bosch D9210B Access Control Interface Module

- J. Bosch D166 Telephone Jack

- K. Bosch D5215 Memory Expansion board

- L. Bosch ISC-PDL1-W18X Professional Series TriTech Detectors

- M. Bosch DS936 Low Profile Panoramic PIR Detector

- N. Bosch DS778 Long Range PIR Detector

- O. Bosch DS160 REX

- P. Bosch ISN-CSTB-10 Compact Recessed Magnetic Contact

- Q. Bosch ISN-C60 Slim Terminal Surface Magnetic Contact
- R. Bosch D1260 LCD Keypad
- S. Siren
 - 1. 8 ohm indoor speaker
 - 2. 15 Watt continuous, 20 Watt peak
 - 3. Siren driver
- T. Cabling: Per manufacturer's recommendations based on cable length and wiring topology.

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions: Examine conditions under which Intrusion Detection cabling and equipment and related components are to be installed in coordination with Installer of materials and components specified in this Section and notify affected Prime Contractors and Design consultant in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected to ensure a safe and timely installation.
 - 1. When Installer confirms conditions as acceptable to ensure proper and timely installation and to ensure requirements for applicable warranty or guarantee can be satisfied, submit to Design consultant written confirmation from applicable Installer. Failure to submit written confirmation and subsequent installation will be assumed to indicate conditions are acceptable to Installer.
 - 2. Visit Site to identify and become familiar with existing field conditions and specific requirements of each Site.
 - 3. Verify all dimensions in field and confirm condition of existing hardware to be utilized.
 - 4. Confirm space requirements and physical confines of all work areas to ensure that all materials can be installed in indicated spaces.
 - 5. Confirm all outlet locations and cable pathways and advise Design consultant in writing of any discrepancies or issues in Design described in Contract Documents.

3.2 PREPARATION

- A. Protection: Provide adequate protection of equipment and hardware before and after installation.
- B. Existing Intrusion Detection Equipment: Ensure all systems remain operational throughout the project.
 - 1. Identify any circuits and/or wiring at the site not shown on drawings and interfering with installation of specified Equipment.
 - 2. Tag all communications cabling not terminated at both ends but retained for future use.

3.3 INSTALLATION

- A. Contractor must collaborate with BCPS Security, IT and/or the current vendor for programming, testing and commissioning in the central station for all security systems.

- B. Provide and install all components necessary to install a complete expansion of existing Intrusion Detection System, including (but is not limited to) connectors, sensors, panels, power supplies, terminators, etc.
1. Cable runs shall be per manufacturer's recommendations in all cases. Any deviation will result in system rejection.
 2. Secure all horizontal cables within ceiling cavities to building structure.
 3. Loosely bundle all cables and support from structure at unequal intervals from 5 to 6 feet with spring steel fasteners and cable clip rated for use with high performance cables where cable tray or other support structure has not been provided as indicated on Drawings. All mounting clips shall be seismic type as per IBC.
 4. Do not violate manufacturer's recommended loadings. Leave 30% capacity for future use of pathway.
 5. Do not support cables from ceiling grid T-Bars, grid wire supports or bridle rings. Do not allow cables to touch ceiling grid.
 6. Install cables in EMT conduit in all unfinished, exposed areas as shown in plans, unless alternate pathways are noted.
 7. Do not secure cables with permanent cable ties. Do not tighten cable bundles in such a way as to cause jacket deformation or damage.
 8. Place cables in compliance with TIA/EIA-568.B standards and BICSI recommended methods.
 9. Tight 90-degree bends are unacceptable, and use of plastic "cinch-type" tie-wraps are not permitted, in order to prevent damage to cable jacket and compromise the cable's electrical or optical characteristics.
 10. Cable bundles shall be neatly routed with a service loop to provide 10 feet of slack at the cross-connect end and as noted in the drawings. Cable bundles shall be secured using only black Velcro cable wraps.
- C. Install all exposed cabling in surface raceway by Wiremold, Hubbell or Panduit where in-wall conduit has not been provided. Follow all manufacturers' guidelines requirements regarding bending radius and slack. All bends, offsets and fittings shall be appropriately sized to provide 30% capacity after installation.
- D. Install all cable in accordance with National, state and local codes and TIA/EIA Standards, and BICSI methods.
1. Follow manufacturer's guidelines and requirements for all cable termination.
 2. Identification: Provide permanent identification labels for patch panels, access panels and entrance facilities.

3.4 TESTING

A. Intrusion Detection System

1. Upon completion of work, all parts of Intrusion Detection System installation shall be tested by the installing Contractor and demonstrated free of any defects. Preliminary testing will be permitted but shall not be accepted in lieu of obtaining final test results. Final test results shall be accomplished by the use of proper test equipment for the system being tested.
2. Each device shall be demonstrated to individually alarm and pin point the exact triggered sensor. Any system failing this requirement will be wholly rejected at the contractor's expense.
3. Re-terminate and re-test any cables or pairs of cables failing end-to-end testing requirements. Replace any faulty cables/pairs or termination devices. Remove all defective cables completely from pathways.
4. Accurate as-built drawings shall be provided in electronic and hard copy format.

- a. 1 copy of electronic (CAD) drawings shall be distributed on disk.
- b. 3 hard copies of CAD drawings shall be plotted on full size sheets and test results of every installed cable have been given to the construction management for appropriate distribution.

3.5 ACCEPTANCE

A. Contractors work shall be considered complete after the following conditions have been met:

1. Cable and equipment installation is complete and all devices and runs have been tested and documented to be installed according to specifications and drawings.
2. A school district Security and Technology representative has successfully tested the "LIVE" system.
3. All punch list items have been reconciled.
4. All disturbed ceiling panels, covers, etc. have been properly reinstalled.
5. All materials and trash have been removed from the site.
6. A 1-Year Installers warranty has been given to a school district Security and Technology representative.
7. Submit Manufacturers Extended Warranty Application.

END OF SECTION 281600

SECTION 283100 - FIRE DETECTION AND ALARM SYSTEMS

PART 1 - GENERAL

1.11 SECTION INCLUDES

- A. Provide a complete fire detection and alarm system of the noncoded, addressable, analog type, with manual stations, detectors, notification appliances, controls, and devices.
- B. Costs of certification and testing, including tests required by NFPA 72, shall be included in the contract sum.

1.12 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Duct smoke detectors: Section 230913.

1.14 RELATED SECTIONS

- A. Division 08 section specifying door hardware for coordinating electrical hardware operators.
- B. Section 211000 for fire suppression system, for coordinating flow, pressure, and valve tamper switch requirements.

1.21 DEFINITIONS

- A. FACP: Fire alarm control panel.
- B. HVAC: Heating, ventilation, and air-conditioning.
- C. LED: Light-emitting diode.
- D. SPDT: Single pole, double throw.
- E. Definitions in NFPA 72 apply to fire alarm terms used in this section.

1.25 SYSTEM DESCRIPTION

- A. Control of system: By the FACP.
- B. System supervision: Automatically detect and report open circuits, shorts, and grounds of wiring for initiating device, signaling line, and notification-appliance circuits.
- C. Priority of signals: Automatic alarm response functions resulting from an alarm signal from one zone or device are not altered by subsequent alarm, supervisory, or trouble signals. An alarm signal is the highest priority. Supervisory and trouble signals have second- and third-level priority. Higher-priority signals take precedence over signals of lower priority, even when the lower-priority condition occurs first. Annunciate and display all alarm, supervisory, and trouble signals regardless of priority or order received.
- D. Noninterference: A signal on one zone shall not prevent the receipt of signals from other zones.
- E. System reset: All zones are manually resettable from the FACP after initiating devices are restored to normal.

- F. Transmission to remote alarm receiving station.
- G. System alarm capability during circuit fault conditions: System wiring and circuit arrangement prevent alarm capability reduction when a single ground occurs in an initiating device circuit, signal line circuit, or notification-appliance circuit.
- H. Loss of primary power at the FACP initiates a trouble signal at the FACP. The FACP indicates when the fire alarm system is operating on the secondary power supply.
- I. Basic alarm performance requirements: Unless otherwise indicated, operation of a manual station, automatic alarm operation of a smoke or heat detector, or operation of sprinkler flow switch, initiates the following:
 - 1. Notification-appliance operation.
 - 2. Identification at the FACP and the remote annunciator of the zone and device originating the alarm.
 - 3. Release of fire and smoke doors held open by magnetic door holders.
 - 4. Operation of duct smoke detector shall initiate a supervisory signal and shutdown of fans and other air-handling equipment serving zone where alarm was initiated.
 - 5. Recording of the event in the system memory.
 - 6. Initiate the transmission of alarm to the Owner's remote alarm receiving station.
- J. In addition to functions mentioned above, elevator smoke detectors shall perform elevator recall functions in accordance with ANSI requirements. Elevator heat detectors shall activate the shunt trip breakers.
- K. Upon activation of alarm signal, the system shall override any intercommunications sound system, public address sound system, theatrical sound system, or local sound system.
- L. Alarm silencing, system reset and indication: Controlled by switches in the FACP and the remote annunciator.
 - 1. Silencing-switch operation halts alarm operation of notification appliances and activates an "alarm silence" light. Display of identity of the alarm zone or device is retained.
 - 2. Subsequent alarm signals from other devices or zones reactivate notification appliances until silencing switch is operated again.
 - 3. When alarm-initiating devices return to normal and system reset switch is operated, notification appliances operate again until alarm silence switch is reset. System reset shall be controlled only at the FACP.
- M. Remote detector sensitivity adjustment: Manipulation of controls at the FACP causes the selection of specific addressable, analog smoke detectors for adjustment, display of their current status and sensitivity settings, and control of changes in those settings. Same controls can be used to program repetitive, scheduled, automated changes in sensitivity of specific detectors. Sensitivity adjustments and sensitivity-adjustment schedule changes are recorded in system memory.
- N. Removal of an alarm-initiating device or a notification appliance initiates the following:
 - 1. Transmission of trouble signal to remote alarm receiving station.

- O. FACP alphanumeric display: Plain-English-language descriptions of alarm, supervisory, and trouble events; and addresses and locations of alarm-initiating or supervisory devices originating the report. Display monitoring actions, system and component status, system commands, programming information, and data from the system's historical memory.

1.30 SUBMITTALS

A. General:

- 1. Comply with Division 01 and Section 280101. When approved, no variation will be permitted except with the approval of the Architect.
- 2. Submit to the authority having jurisdiction and to the Architect for review and approval.

B. Shop drawings:

- 1. Floor plans indicating final equipment and device locations and raceway routes.
- 2. System operation description: Detailed description for this project, including method of operation and supervision of each type of circuit and sequence of operations for manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are not acceptable.
- 3. Details of graphic display.
- 4. Wiring diagrams and riser diagrams.

- C. Product data: Schedule and each type of system component, including dimensioned plans and elevations showing minimum clearances and installed features and devices. Include UL listings.

D. Battery calculations.

- E. Provide a complete project record drawing as specified in Division 01 and Section 280101 showing the location of all the outlets, cable taps, cable routes, and other components installed. Drawings shall be made part of Operating and Maintenance Manuals.

F. Certifications:

- 1. UL Certificate of Compliance of system supplier as specified in "Quality Assurance" below.
- 2. Fire and smoke detection system inspection and test report, completed by the factory representative, endorsed by the Owner and the factory representative, including test data, detector locations and serial numbers, a summary of maintenance performed, recommendations for relocation or addition of detectors and final action regarding these recommendations, and system certification.

1.40 QUALITY ASSURANCE

- A. System and equipment shall be UL listed. Each major component shall bear the manufacturer's name and catalog number.
- B. UL labels and local testing (if required): As specified in Section 280500, Common Work Results for Electronic Safety and Security.
- C. Single-source responsibility: Obtain system components from a single source who assumes responsibility for their compatibility.
- D. Qualifications of system supplier and installer:

1. Staff shall consist of at least one NICET Level II Technician or a professional engineer registered in Maryland.
 2. Has installed at least ten systems of the type specified which have performed satisfactorily for not less than two years.
 3. Maintains a facility with a sufficient stock of spare parts.
 4. Shall respond within 24 hours of notification to correct system failure or malfunction. During the project correction period defined in General Conditions and in Section 280500, perform such corrections at no addition to the Contract Sum.
- E. Factory-authorized service representative: Trained and certified by the manufacturer of the system, and experienced in the installation and operation of the type of system included in the work.
- F. Comply with NFPA 72, applicable local codes, and regulations and requirements of the authorities having jurisdiction. Baltimore County is the local code authority.

1.91 INSPECTIONS AND SERVICE CONTRACT

- A. During the general project correction period, every six months starting six months after Substantial Completion, the supplier shall inspect and test the system.
1. Submit written reports to the Owner and Architect, describing test results, including defects found and how they have been corrected, and listing components replaced.
- B. At the end of the correction period, offer the Owner a service contract for the complete system.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design system: Subject to compliance with requirements, provide system by Fire-Lite Alarms (Honeywell) or comparable system by one of the following:
1. Edwards Systems Technology, Inc. A GE-UTC Fire and Security
 2. Fire-Lite Alarms, Inc.; Honeywell
 3. Silent Knight; Honeywell

2.20 FIRE ALARM CONTROL PANEL

- A. Cabinet: Lockable steel enclosure. Arrange interior components so operations required for testing or for normal maintenance of the system are performed from the front of the enclosure. If more than one unit is required to form a complete control panel, fabricate with matching modular unit enclosure to accommodate components and to allow ample gutter space for field wiring and interconnecting panels.
1. Mounting: Surface.
- B. Alarm and supervisory systems: Modules replaceable without removal of field wiring.
- C. Control modules: Include types and capacities required to perform all functions of fire alarm systems.
- D. Indications: Local, visible, and audible signals announce alarm, supervisory, and trouble conditions. Each type of audible alarm has a different sound.

- E. Resetting controls: Prevent the resetting of alarm, supervisory, or trouble signals while the alarm or trouble condition still exists.
- F. Alphanumeric display and system controls: Arranged for interface between human operator at the FACP and addressable system components, including annunciation, supervision, and control.
 - 1. Display: A minimum of 80 characters; alarm, supervisory, and component status messages; and indicate control commands to be entered into the system for control of smoke detector sensitivity and other parameters.
 - 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.

2.21 EMERGENCY POWER SUPPLY

- A. General: Components include nickel-cadmium battery, charger, and an automatic transfer switch.
 - 1. Battery nominal life expectancy: 20 years, minimum.
- B. Battery capacity: 24 hours of supervisory power with 15 minutes of general alarm capability at end of 24 hours.
- C. 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.
- D. Integral automatic transfer switch: Transfers the load to the battery without loss of signals or status indications when normal power fails.

2.22 ONE-WAY VOICE COMMUNICATION

- A. The system shall have one-way voice communication and tone-generating capabilities. The voice messaging system shall be of the same manufacturer as the control panel.
- B. Central audio control module: Alarm message or tone generation and microphone connections with continuous supervision and identification of the type of failure should a problem occur (e.g. main microphone trouble, tone trouble). Audio outputs shall have individual gain control.
- C. Hand-held, push-to-talk microphone: Recessed within a protective panel-mounted enclosure, noise-canceling communication type with a frequency range of 200 Hz to 4000 Hz, equipped with a self-winding five-foot coiled cable. An LED indicator shall indicate the microphone push-to-talk button has been pressed and speaker circuits are ready for transmission. The microphone shall be supervised for disconnection.
- D. Audio control switch and indication module: To provide manual access to audio operations for authorized personnel. Include a phone page select switch, tone select switch, tape select switch, and "Audio trouble Reset switch". These switches and associated LED indicators shall be supervised for disarrangement or failure.
- E. Audio power amplifiers: Furnished with a self-contained filtered 24 Vdc power supply, transformer, and amplifier monitor circuits. The amplifiers shall provide a 25-V rms output with a frequency response of 120 Hz to 12,000 Hz. Provide sufficient amplification to operate all system speakers simultaneously plus 10 percent spare capacity.

- F. Backup amplifier: Capable of automatically replacing any failed amplifier.
- G. Speaker circuits: Capable of supplying 25-V rms audio power from the system amplifiers. Provide supervision for open, short, or ground fault conditions; individual and distinct trouble indications for each fault; and one circuit for each zone or area of distinct communication.
- H. Digitized tones: For alarm (slow whoop) and auxiliary requirements (wail, horn, chime, and others).
- I. Pre-recorded digitized voice message capability: Automatically transmitted to occupants during alarm conditions.
 - 1. The automatic message player shall not rely on a tape or other mechanical means of transmitting the evacuation message.
 - 2. Provide a standard evacuation message, and message transmitter capable of transmitting a custom message up to 30 seconds long. A self-contained speaker shall provide testing of the message(s) without disturbing the occupants of the facility.
- J. Automatic voice evacuation sequence:
 - 1. Alarm tone shall sound for a maximum of 15 seconds, followed by automatic preselected voice evacuation messages. At the end of each voice evacuation message, the alarm tone shall resume. The alarm tones shall sound alternately until the Alarm Silence Switch at the FACP has been operated.
 - 2. Audible alarm operations (speaker circuit selection and alarm tone and voice message timing variations) shall be activated by the system software so that changes to the evacuation sequence can be made by authorized personnel without any component rewiring.
- K. Manual voice paging sequence:
 - 1. The system shall allow voice paging. Upon activation of speaker manual control switch, attention-getting beeps shall sound over the speakers indicating an impending voice message.
 - 2. Voice message: Operator shall be able to make announcements via the push-to-talk paging microphone.

2.24 REMOTE ANNUNCIATOR AND GRAPHIC DISPLAY

- A. Remote annunciator: Flush-mounted liquid crystal display (LCD) annunciator.
 - 1. Display: Supervised, back-lit, LCD with no fewer than 4 lines with 20 characters per line.
 - a. Back lighting shall turn off after 4 minutes when there is no switch activity and no unacknowledged message.
 - b. The first event of the highest priority shall capture the display, so that arriving firefighters can view the first alarm event immediately.
 - 2. Key operated switches:
 - a. Alarm silence.
 - b. Trouble silence.
 - c. Test

B. Description: Duplicate annunciator functions of the FACP for alarm, supervisory, and trouble indications. Also duplicate manual switching functions of the FACP, including alarm silence, trouble silencing, and test.

1. Mounting: Recessed cabinet, NEMA 250, Type 1.

C. Graphic display: As shown on drawings, panel indicating the building floor plan with a "You are here" note and zone and device locations permanently marked on panel surface.

1. Mounting: Integral with remote annunciator, with individual lamps in locations shown.

2. Dimensions: 24-inches wide by 18-inches high.

2.25 MANUAL PULL STATIONS

A. Description: Fabricated of metal or plastic, and finished in red with molded, raised-letter operating instructions of contrasting color.

1. Single-action mechanism initiates an alarm.

2. Station reset: Key or wrench operated; double pole, double throw; switch rated for the voltage and current at which it operates.

3. Integral addressable module: Arranged to communicate manual-station status (normal, alarm, or trouble) to the FACP.

4. False alarm protector: Tamperproof clear polycarbonate shield in a frame that fits over the pull station. When the shield is lifted to gain access to the pull station, a warning horn shall sound. Include 9-V dc alkaline battery.

2.26 SMOKE DETECTORS

A. General: UL 268A listed. Include the following features:

1. Operating voltage: 24-V dc, nominal.

2. Self-restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.

3. 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.

4. Integral visual-indicating light: LED type. Indicates detector has operated.

5. Sensitivity: Can be tested and adjusted in-place after installation.

6. Integral addressable module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.

7. Remote controllability: Unless otherwise indicated, detectors are analog-addressable type, individually monitored at the FACP for calibration, sensitivity, and alarm condition, and individually adjustable for sensitivity from the FACP.

a. Detectors which will be installed in ducts or other concealed locations shall be capable of being tested from an indicating and test station specified below.

B. Photoelectric smoke detectors: Include the following features:

1. Sensor: LED or infrared light source with matching silicon-cell receiver.

2. Detector sensitivity: Between 2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm) smoke obscuration when tested according to UL 268A.

3. Integral thermal detector: Fixed-temperature type with 135 deg F (57 deg C) setting.

C. Duct smoke detector: Photoelectric type.

1. Sampling tube: Design and dimensions as recommended by the manufacturer for the specific duct size, air velocity, and installation conditions where applied.
2. Relay fan shutdown: Contacts rated to interrupt fan motor-control circuit.

2.27 OTHER DETECTORS

A. Heat detector, fixed-temperature type:

1. Actuated by temperature that exceeds a fixed temperature of the following:
 - a. Elevator shaft and elevator machine room: 135 degrees F (57 degrees C).
 - b. Other locations or where indicated on drawings:190 degrees F (88 degrees C).
2. Mounting:
 - a. Adapter plate for outlet box mounting.
 - b. Plug-in or twist-lock base, interchangeable with smoke detector bases.
3. Integral addressable module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.

2.28 CONCEALED DETECTOR INDICATING AND TEST STATION

- A. Description: Flush-mounted, single-gang station for each duct smoke detector and other detector that is not readily visible, with indicating light and test switch.
- B. Indicating light: Flashes when the associated device is in an alarm or trouble mode.
- C. Test switch: Forces detector into alarm, allowing test of outputs programmed to occur following alarm initiation at devices.
- D. Device plate: Red plastic with engraved white letters reading SMOKE DETECTOR ABOVE CEILING, or other text as appropriate.

2.29 NOTIFICATION APPLIANCES

- A. Description: Equipped for mounting as indicated and have screw terminals for system connections.
 1. Combination devices: Factory-integrated audible and visible devices in a single-mounting assembly.
 - B. Visible alarm devices: Synchronized xenon strobe lights listed under UL 1971 with clear or nominal white polycarbonate lens. Mount lens on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on a removable sleeve on the lens.
 1. Rated light output: Indicated on drawings for each location.
 2. Strobe leads: Factory connected to screw terminals.
- C. Speakers:
 1. UL 1480 listed.

2. Sound output: Minimum of 84 dBA at 10 feet when tapped at 0.5 watt, and maximum of 87 dBA at 10 feet. Taps shall be available at 0.25, 0.5, 1, and 2 watts.
 3. 25 or 70.7 V rms.
 4. Mounting: Flush or surface-mountable; bidirectional as indicated, with sealed back.
 5. Operation: From standard signaling circuits or addressable single- or multizone I/O modules.
- D. Combination speaker/strobe units: Speaker and visible alarm device as specified above, mounted in a fire-retardant, high-impact, white polycarbonate housing suitable for flush or surface mounting.
1. Speaker: Tapped at 0.5 watts; 25 V rms.

2.30 FIRE ALARM NOTIFICATION BOOSTER

- A. Power supply booster designed to extend power available to notification appliance circuits.
- B. Enclosure: Steel, with lockable front panel allowing access to all interior components, surface-mounted.
- C. Functions: Contains circuits to monitor and charge batteries, control and supervise 4 Class B appliance circuits, and monitor two controlling inputs from external sources.
 1. Configurable to operate at any one of three signaling rates, or to follow the main panel's notification appliance circuit.
 2. Trouble contact with 16-second delay.
- D. Batteries: Two, sized for 24 hours of standby followed by 15 minutes of alarm.
- E. Indicators: LEDs, one for each circuit, one for battery supervision, one for ground fault, and one for power.

2.31 MAGNETIC DOOR HOLDERS

- A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching door plate.
 1. Electromagnet: Requires no more than 3 W to develop 25-lbf (111-N) holding force.
 2. Wall-mounted units: Flush mounted, unless otherwise indicated.
 3. Rating: 24-V ac or dc.
- B. Material and finish: Match door hardware.

2.32 ADDRESSABLE INTERFACE DEVICE

- A. Monitor module: Microelectronic monitor module listed for use in providing a system address for external alarm-initiating devices with normally open contacts.
 1. Dual circuit, intelligent, signaling circuit interface module.
- B. Control module: Microelectronic control relay module listed for use in providing control to external appliances or equipment shutdown to elevator controller to initiate elevator recall and to circuit-breaker shunt trip for power shutdown.
 1. One Form C (SPDT) dry relay contact rated at 2 amps and 24 volts DC.

- C. Isolator module: Microelectronic fault isolator module listed for isolating and removing a fault from a data circuit while allowing the remaining data loop to continue operating.
 - 1. Protect loop system against wire-to-wire short circuits by isolating section of loop and permitting other loop sections to continue to operate.
- D. Non-addressable control relay: Isolation relay for the control of HVAC unit contactors, magnetic door holders, and elevator recall circuits, UL 864 Listed.
 - 1. Construction: Sealed, non-removable, with terminations to pressure-type screw terminals.
 - 2. Rating: Use with circuits up to 240 volts AC at 7amperes inductive.

2.33 WIRE AND WIRING SYSTEM

- A. Non-power-limited circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.
 - 1. Low-voltage circuits: No. 16 AWG, minimum.
 - 2. Line-voltage circuits: No. 12 AWG, minimum.
- B. Power-limited circuits: NFPA 70, Types FPL, FPLR, or FPLP, as recommended by manufacturer.
- C. Wiring system: Class B in accordance with NFPA 72.
- D. Type MC fire alarm cable: Equal to AFC Cable Systems FPLP metal-clad, multi-conductor, fire alarm and control cable.
 - 1. Ratings:
 - a. Plenum rated.
 - b. Approved for use as fixed wiring concealed in building.
 - c. Maximum operating temperatures:
 - (1) 105 degrees C dry for FPLP applications at nominal voltage ratings 300 V and less.
 - (2) 90 degrees C dry for MC cable installations at nominal voltage ratings of 600 V and less.
 - d. UL listed for penetrations of wall and floor assemblies of gypsum wallboard, concrete, and concrete masonry with one-, 2-, and 3-hour fire ratings.
 - 2. Shield over conductor assembly: Laminated aluminum and mylar tape and tinned copper drain wire.
 - a. Drain wire: Minimum No. 18 AWG, in contact with aluminum shield.
 - 3. Listed in accordance with UL 1596:
 - a. Insulated or bare grounding conductor in accordance with Table 6.3, cabled with the circuit conductors and identified in compliance with Section 35.
 - b. Galvanized steel armor, red, applied over inner cable assembly with positive interlock conforming to the requirements of Section 12.
 - c. Tested in accordance with applicable requirements.

- E. Survivability: Circuits necessary for the operation of notification appliances shall be protected by a 2-hour fire-rated cable, a 2-hour fire-rated cable system, or a 2-hour fire-rated enclosure.

2.34 PERIPHERAL EQUIPMENT

- A. Alarm reporting device: A digital communicator shall report an alarm or trouble condition. It shall notify Owner's fire alarm monitoring service and one or more facilities personnel. Provide unit compatible with the Owner's monitoring service.
- B. Sprinkler flow and tamper switches: Specified in fire suppression sprinkler system specifications. Provide a monitor module for addressing each device. Unit shall mount on 4-inch-square, 2.5-inch-deep back box.

PART 3 - EXECUTION

3.20 INSTALLATION, GENERAL

- A. Factory-authorized service representative, as required in "Quality Assurance" in Part 1 above, shall supervise installation, software documentation, adjustment, preliminary testing, final testing, and certification of the system, and provide the operating instructions.
- B. Provide wiring, conduit, and outlet boxes required for the complete system, in accordance with system manufacturer's instructions and with requirements specified in Division 26 for wiring, conduit, and boxes. Provide 12 inches of slack at each outlet.
 - 1. Install all wiring in conduit, except where noted on drawings to provide Type MC fire alarm cable.
 - 2. Install Type MC fire alarm cable in accordance with Article 330 of the National Electric Code (NFPA 70).
 - 3. Identification: Paint fire alarm junction box covers red.
- C. Wires, cables, conduits, and wiring connections are specified in Division 26, Electrical. Include in the work of this section, wiring, conduits, and equipment connections complying with the requirements of Division 26, so that the fire alarm system will function as specified and indicated on the drawings.
- D. Wiring: Free from grounds or crosses between conductors.
 - 1. Identification: Color code wiring, not duplicating building wiring colors. Tag each wire at each junction point.
- E. Final connections between equipment and the wiring system shall be made under the direction and supervision of the qualified supplier.
- F. Provide 20 percent spare capacity for each notification appliance circuit.
- G. Locate 135 degree F (57 degree C) rated heat detectors in elevator shaft and elevator machine room within 18 inches (457 mm) of sprinklers.

3.21 INSTALLATION, FIRE ALARM NOTIFICATION BOOSTER

- A. Provide number of notification power supply boosters required for a complete fire alarm system.

- B. Utilize spare single-pole, 20-ampere circuit breaker in a 120-volt emergency electrical panelboard to make electrical connection to each power supply booster.
 - 1. Circuit breakers shall match and shall be compatible with the other breakers in the panelboard.
- C. Branch circuits from panelboards to each notification power supply booster: Two No. 10 wires and one No. 10 ground in conduit no less than 0.75 inch (21-mm) trade size.
- D. Install conduits and wiring as specified in Sections 260519 and 26 0533.
- E. Provide smoke detector above each power supply booster.

3.22 INTERFACE WITH OTHER WORK

- A. Furnish duct smoke detectors to be installed as part of ductwork specified in Division 23.
- B. Coordinate with installation of flow and tamper switches in fire suppression sprinkler system.
- C. Coordinate with sprinkler contractor for number and locations of sprinklers in elevator shaft and elevator machine room.
- D. Coordinate locations of control modules for connections to sound systems override.

3.23 LOCATIONS OF FIRE ALARM EQUIPMENT

- A. Locate the control panel, annunciator, and other associated equipment as shown on the drawings.
- B. Visual indicating appliances: Install where shown on the drawings. If field conditions require variation from drawings, do not violate ADA requirements, including, but not limited to, the following:
 - 1. Any room or space required to have a visual appliance, including corridors or hallways: No place shall be more than 50 feet from the indicating appliance in the horizontal plane.
 - 2. Rooms and spaces exceeding 100 feet in one dimension, without obstructions 6 feet above the finished floor: Indicating appliances may be placed around the perimeter, spaced approximately 100 feet apart.
- C. Mount indicating and test station for concealed smoke detectors near ceiling under detector. Text engraved on plate shall be descriptive of the device identified.
- D. Provide a smoke detector at each fire alarm panel location, including but not limited to main control, auxiliary control, and power panels.

3.60 INSPECTION, TEST, ADJUSTMENT AND REPORT

- A. Furnish equipment and appliances for testing the complete system during progress of the work and after completion of the installation, including a megger test of wiring. The tests generally shall demonstrate the following:
 - 1. Circuits are continuous and free from short circuits.
 - 2. Circuits are free from unspecified grounds.
 - 3. Resistance to ground of non-grounded circuits is not less than one megohm.
 - 4. Circuits are properly connected in accordance with the applicable wiring diagrams.

5. Each detector operates correctly.
6. Detectors are correctly located and sufficient in number.

B. Defects or omissions observed during general and system tests shall be repaired as quickly as possible and the tests reconducted.

C. Submit report as required in Part 1 above.

3.81 OPERATING INSTRUCTIONS

A. As specified in Section 280500, provide operating instructions.

B. Provide at least 8 hours of additional instruction time for the systems and equipment specified in this section, consisting of 2 periods of 4 consecutive hours, during a period of not more than 60 days.

END OF SECTION 283100

SECTION 31 10 00 - SITE CLEARING

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. Delineation of Site Clearing and Required Approvals.
2. Protecting existing trees and vegetation to remain
3. Removing trees and other vegetation
4. Clearing and grubbing.
5. Topsoil stripping.
6. Removing above-grade site improvements.

- B. Related Requirements:

1. Division 31 Section "Earthwork" for soil materials, excavating, backfilling, and site grading.
2. Division 01 Section "Tree Protection and Trimming."
3. Division 32 Section "Landscaping" for finish grading, including placing and preparing topsoil for lawns and planting.

1.3 DEFINITIONS

- A. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches in diameter; and free of weeds, roots, and other deleterious materials.

1.4 MATERIALS OWNERSHIP

- A. Materials shall become Contractor's property and shall be removed from the site.

1.5 SUBMITTALS

- A. Photographs or videotape, sufficiently detailed, of existing conditions of trees and
- B. Plantings, adjoining construction, and site improvements that might be misconstrued as damage caused by site clearing.

- C. Record drawings. Identify and accurately locate capped utilities and other subsurface structural, electrical, and mechanical conditions. This information shall be included on the "As-built Survey" required under Division 01 Section "Execution Requirements".

1.6 QUALITY ASSURANCE

- A. Pre-installation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Meetings" and paragraph.

1.7 PROJECT CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent
 - 1. Occupied or used facilities during site-clearing operations. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
 - 2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
- B. Protection of Existing Improvements: Provide protection as required to prevent damage
 - 1. To existing improvements indicated on the drawings to remain in place. Protect improvements on adjoining properties and on Owner's property.
 - 2. Restore damaged improvements to their original condition, as acceptable to the respective property owner.
- C. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.
- D. Notify "Miss Utility" (telephone: 1-800-257-7777) for field marking of existing utilities before commencement of site clearing.
- E. Employ the services of a private utility locator and test pit as required by the drawings.

PART 2 - PRODUCTS (As required to complete the Work)

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect and maintain project benchmarks and survey control points from disturbance throughout the construction period.
- B. Stake-out and delineation prior to the Pre-construction Meeting with Owner representatives and before commencement of site clearing:
 - 1. Stake-out of the Limit of Disturbance (L.O.D.) and sediment control measures;

2. Stake-out tree protection fencing and mark the ground with florescent yellow paint the areas to be root pruned;
 3. Mark with florescent orange paint all paving, curbs, steps, walks, utility structures, appurtenances, and vegetation to be removed;
 4. Mark with florescent yellow surveyor's flagging all light fixtures and other existing site amenities indicated on the drawings to be salvaged; tag and enumerate as "Salvage #__" (assign numbers);
 5. Identify and mark any other vegetation, improvements, or obstructions that the contractor believes are necessary to remove (in whole or part) in order to permit installation of new construction.
- C. Pre-construction Approval of Site Clearing: After completing the procedures set forth in paragraph 3.1.B., and before beginning any clearing, demolition, construction or installation of sediment control measures, arrange and conduct an on-site meeting with the Owner representative and the project landscape architect to observe the markings, stake-out and other items delineated as required by the above procedures. In addition to the general contractor and Owner representative and the project landscape architect, the on-site meeting must be attended by the individual(s) who will be directly supervising the installation of sediment control measures, grading and installation of storm drains, as well as the arborist contracted to complete root pruning and limb pruning; the contractor shall identify and discuss any other vegetation, improvements, or obstructions which the contractor believes are necessary to remove (in whole or part) in order to permit installation of new construction. Do not begin clearing until receiving written approval from the Owner representative following the meeting.
- D. Install erosion-control measures in accordance with the approved drawings to prevent soil erosion and discharge of soil-bearing water runoff and airborne dust to adjacent properties and public rights-of-way.
- E. Install the temporary construction fence in accordance with the demolition plan and the sediment control plans.
- F. Protect existing site improvements to remain from damage during construction.
1. Restore damaged improvements to their original condition, as acceptable to the Owner's Representative.
- 3.2 UTILITIES
- A. Owner will arrange for disconnecting and abandoning indicated utilities that serve existing structures before site clearing when requested by Contractor.
1. Verify that utilities have been disconnected and capped before proceeding with site clearing.
- B. Locate, identify, disconnect, and seal or cap off utilities to be removed as indicated in Division 33 Section "Common Work Results for Utilities".
1. Owner will arrange to shut off indicated utilities when requested by Contractor. Arrange to shut off indicated utilities with utility companies.
- C. 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 in Division 33 Section "Common Work Results for Utilities".

1. Notify Owner's Representative not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Owner's Representative's written permission.

D. Excavate for and remove underground utilities indicated to be removed

3.3 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction. Removal includes digging out stumps and obstructions and grubbing roots.

1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
2. 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.
3. Completely remove stumps, roots, obstructions, and debris extending to a minimum depth of 18 inches below exposed subgrade.
4. Use only hand methods for grubbing within drip line of remaining trees.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material, unless further excavation or earthwork is indicated.

1. Place fill material in horizontal layers not exceeding 8-inch loose depth, and compact each layer to a density equal to adjacent original ground.

3.4 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.

1. Strip surface soil of unsuitable topsoil, including trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil materials away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Limit height of topsoil stockpiles to as approved by the Owner's Representative.
2. Do not stockpile topsoil within drip line of remaining trees.
3. Dispose of excess topsoil as specified for waste material disposal.
4. Stockpile surplus topsoil and allow for respreading deeper topsoil, if approved by the Owner's Representative.

3.5 SITE IMPROVEMENTS

- A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.
- B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated and as required for new construction.
- C. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.

3.6 DISPOSAL

- A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, waste materials including trash and debris, and legally dispose of them off of the Owner's property.

END OF SECTION 31 10 00

SECTION 31 20 00 – EARTHWORK

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. Preparing subgrades for slabs-on-grade, walks, pavements, lawns, and plantings.
2. Excavating and backfilling for buildings and structures.
3. Drainage course for slabs-on-grade.
4. Subsurface drainage backfill for walls and trenches.
5. Excavating and backfilling trenches within building lines.
6. Excavating and backfilling trenches for buried utilities and pits for buried utility structures.
7. Fine grading, scarifying and removal of stones from subgrade.
8. Furnishing and spreading of topsoil.
9. Preparation for seeding and sodding of lawn areas.
10. Disposal of surplus topsoil.

- B. Related Sections include the following:

1. Division 01 Section "Unit Prices" for a schedule of unit prices.
2. Division 01 Section "Temporary Facilities and Temporary Controls."
3. Division 31 Section "Site Clearing" for site stripping, grubbing, removing topsoil, and existing features.
4. Division 31 Section "Sediment and Erosion Control" for installation and maintenance of sediment and control devices.
5. Division 31 Section "Subdrainage" for drainage of foundations, slabs-on-grade, and walls.

- C. Expansive Clay Soils

The site contains expansive clay soils, as such, all slabs and pavements will require undercutting to a depth of 12 inches, and placement of a granular compacted structural fill. Clay subgrades cannot be allowed to change moisture content. Therefore, any clay subgrades should be filled or covered immediately upon exposure. Note that backfill for utility pipes entering the building will require flowable fill backfill, and that exterior footings will require flowable fill backfill. If earthwork operations are to be conducted in an expected wet season (November to April), the use of cement stabilization should be considered.

1.3 UNIT PRICES

- A. Unit prices for earthwork are included in Division 01 Section "Unit Prices."

- B. Quantity allowances for earthwork are included in Division 01 Section "Allowances."
- C. All excavation on this project shall be UNCLASSIFIED.

1.4 DEFINITIONS

- A. Backfill: Soil materials used to fill an excavation.
 - 1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
 - 2. Final Backfill: Backfill placed over initial backfill to fill a trench.
- B. Borrow: Satisfactory soil imported from off-site for use as fill or backfill.
- C. Drainage Course: Layer supporting slab-on-grade used to minimize capillary flow of pore water.
- D. Excavation: Removal of material encountered above subgrade elevations.
 - 1. Additional Excavation: Excavation below subgrade elevations as directed by Geotechnical Engineer. Additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
 - 2. Bulk Excavation: Excavations more than 10 feet in width and pits more than 30 feet in either length or width.
 - 3. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated dimensions without direction by Geotechnical Engineer. Unauthorized excavation, as well as remedial work directed by Geotechnical Engineer, shall be without additional compensation.
- E. Compacted Structural Fill: Soil materials approved by the Geotechnical Engineer to be used to raise existing grades.
- F. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, inlets, manholes and utility vaults, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
- G. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below pavement base course, drainage fill, or topsoil materials.
- H. Utilities include on-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.
- I. Flowable Fill: Controlled Low Strength Material (CLSM) consisting of a self-leveling and self compacting Cementous material having a minimum compressive strength of 300 psi.

1.5 DEMOLITION MEETINGS

- A. Demolition Conference: Conduct preexcavation conference at 500 Compass Road, Baltimore, MD 21220

1. Review methods and procedures related to earth moving, including, but not limited to, the following:
 - a. Personnel and equipment needed to make progress and avoid delays.
 - b. Coordination of Work with utility locator service.
 - c. Coordination of Work and equipment movement with the locations of tree- and plant-protection zones.
 - d. Extent of trenching by hand or with air spade.
 - e. Field quality control.

1.6 SUBMITTALS

A. Product Data: For the following:

1. Each type of plastic warning tape.
2. Drainage fabric.
3. Separation fabric.

B. Samples: For the following:

1. 30-lb samples, sealed in airtight containers, of each proposed soil material from on-site or borrow sources.
2. 12-by-12-inch sample of drainage fabric.
3. 12-by-12-inch sample of separation fabric.
4. Sample of borrow topsoil (1/2 cubic foot minimum) provided at the site. Topsoil source shall be approved in writing by the Owner's Representative prior to delivery.

C. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:

1. Classification according to ASTM D 2487 of each on-site or borrow soil material proposed for fill and backfill.
2. Laboratory compaction curve according to ASTM D 698 for each on-site or borrow soil material proposed for fill and backfill.
3. Laboratory compactions curve according to ASTM D 1557 for each on-site or borrow soil material proposed for fill and backfill.
4. Individual test analyses for both stockpiled and borrow topsoil including gradation, organic content, pH and soluble salts.

1.7 QUALITY ASSURANCE

A. Geotechnical Testing Agency Qualifications: An independent testing agency qualified according to ASTM E 329 to conduct soil materials and rock-definition testing, as documented according to ASTM D 3740 and ASTM E 548.

B. Pre-excavation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Meetings."

C. United States Department of Agriculture (U.S.D.A.) Textural Classification Diagram for Soils.

- D. 2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control (MDESESC) published jointly by the Maryland Department of the Environment, Water Management Administration in association with the Soil Conservation Service and the State Soil Conservation Committee, as amended to date.

1.8 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Owner's Representative and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Owner's Representative not less than 48-hours notice in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Owner's Representative's written permission.
 - 3. Contact utility-locator service for area where Project is located before excavating.
- B. Sediment Control Measures, Limits of Disturbance, and Existing Vegetation to Remain: Sediment Control Measures shall be installed in accordance with approved plans and local ordinances before clearing and grading operations begin. Grading operations shall not breach the limits-of-disturbance (L.O.D.) shown on the approved plans, nor shall Contractor disturb (by grading, driving equipment, parking equipment, storing supplies, or otherwise) existing vegetation shown on the plans as "To Remain" or the area protected by tree protection fencing.
- C. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

PART 2- PRODUCTS

2.1 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils: ASTM D 2487 soil classification groups, SM, SP, SW, GM, GP, GW, or a combination of these group symbols; free of rock or gravel larger than 4 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter, as approved by the Geotechnical Engineer. SC and GC material may be used if they contain less than 35% passing the No. 200 sieve, and have a plasticity index less than 15.
- C. Unsatisfactory Soils: ASTM D 2487 soil classification groups GC, SC, MH, CL, ML, CH, OL, OH, and PT, or a combination of these group symbols.
 - 1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.
- D. Backfill and Fill: Satisfactory soil materials.
- E. Base Course: In accordance with the requirements of Division 32 Section "Hot-Mix Asphalt Paving".

- F. Bedding: 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.
- G. Drainage Fill: Washed, narrowly graded mixture of 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.
- H. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1- inch sieve and 0 to 5 percent passing a No. 4 sieve.
- I. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state, as approved by the Geotechnical Engineer.
- J. Topsoil:
 - 1. Borrow Topsoil: In accordance with items II and III (i) if Construction and Materials Specifications, Section G, 21.0 Topsoil of the MDESESC Standards.
 - 2. Stockpiled topsoil, which does not meet the requirements above, or cannot be satisfactorily amended to meet requirements, shall be replaced with suitable borrow topsoil.

2.2 ACCESSORIES

- 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, minimum 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 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.
- C. Drainage 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; ASTM D 4632.
 - 2. Tear Strength: 40 lbf; ASTM D 4533.
 - 3. Puncture Resistance: 50 lbf; ASTM D 4833.
 - 4. Water Flow Rate: 150 gpm per sq. ft.; ASTM D 4491.
 - 5. Apparent Opening Size: No. 50; ASTM D 4751.

- D. Separation Fabric: Woven geotextile, specifically manufactured for use as a separation 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; ASTM D 4632.
 - 2. Tear Strength: 75 lbf; ASTM D 4533.
 - 3. Puncture Resistance: 90 lbf; ASTM D 4833.
 - 4. Water Flow Rate: 4 gpm per sq. ft.; ASTM D 4491.
 - 5. Apparent Opening Size: No. 30; 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 and maintain erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust in accordance with the approved sediment and erosion control plans.
- D. Protect existing vegetation to remain in accordance with the requirements of Division 31 Section "Site Clearing".
- E. Test Pit in accordance with the requirements of the contract documents.

3.2 DEWATERING

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- B. Protect subgrades from softening, undermining, washout, 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 ground water away from excavations. Maintain until dewatering is no longer required.
- C. Remove all standing surface water within 24 hours of each event.

3.3 EXPLOSIVES

- A. Explosives: Explosives may not be employed.

3.4 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, boulders, soil materials of all types and conditions, 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. 60 inches outside of concrete forms other than at footings.
 - b. 12 inches outside of concrete forms at footings.
 - c. 6 inches outside of minimum required dimensions of concrete cast against grade.
 - d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
 - e. 6 inches beneath bottom of concrete slabs on grade.
 - f. 6 inches beneath pipe in trenches, and the greater of 24 inches wider than pipe or 42 inches wide.

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.
1. 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.
 2. Pile Foundations: Stop excavations from 6 to 12 inches above bottom of pile cap before piles are placed. After piles have been driven, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete pile caps.
 3. Excavation for Underground Tanks, Basins, and Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch. Do not disturb bottom of excavations intended for bearing surface.

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated contours, spot elevations, cross sections, and grades. Provide for a minimum of 12 inches of compacted structural fill below walks and pavements.

3.7 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 fire water main and domestic water main pipe a minimum of 4 feet below finish grade, unless shown otherwise on the drawings.
- 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 higher than top of pipe or conduit, unless otherwise indicated.
 1. Clearance: 12 inches on 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.

3.8 APPROVAL OF SUBGRADE

- A. Notify the Geotechnical Engineer when excavations have reached required subgrade.
- B. If the Geotechnical Engineer determines that unsatisfactory soil is present below the design subgrades, continue excavation and replace with compacted backfill or fill material as directed.
 1. Additional excavation and replacement material must be authorized by Baltimore County Public Schools prior to starting.
- C. Proof roll subgrade with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof roll wet or saturated subgrades.
- D. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by the Geotechnical Engineer.
- E. The subgrades shall be protected from either wetting or drying. All subgrades must remain within 2% of the natural moisture content.
- F. Grading, including subgrade contours and elevations, must be approved by the Architect before spreading topsoil and fine grading.

- G. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.

3.9 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill shall be used below footings and drilled shafts or when directed and approved by the Geotechnical Engineer.
 - 1. Fill unauthorized excavations under other construction or utility pipe as directed by the Geotechnical Engineer.

3.10 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow materials and satisfactory excavated soil materials. Stockpile soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 - 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.11 BACKFILL

- A. Place and compact backfill in excavations promptly, but not before completing the following:
 - 1. Acceptance of construction below finish grade including, where applicable, dampproofing, waterproofing, and perimeter insulation.
 - 2. Surveying locations of underground utilities for record documents.
 - 3. Inspecting and testing underground utilities.
 - 4. Removing concrete formwork.
 - 5. Removing trash and debris.
 - 6. Removing temporary shoring and bracing, and sheeting.
 - 7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

3.12 UTILITY TRENCH BACKFILL

- A. 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.
- B. Backfill trenches excavated under footings and within 18 inches of bottom of footings; fill with concrete to elevation of bottom of footings.
- C. 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 subbase.
- D. Place and compact initial backfill of subbase material, free of particles larger than 1 inch, to a height of 12 inches 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.

- E. Coordinate backfilling with utilities testing.
- F. Fill voids with approved backfill materials while shoring and bracing, and as sheeting is removed.
- G. Place and compact final backfill of satisfactory soil material to final subgrade.
- H. Place a minimum of 5 feet (horizontal distance outside the building wall) of flowable fill in the utility trench, such that water cannot migrate through the trench into the building.
- I. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.13 FILL

- A. Preparation: Remove vegetation, topsoil, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface before placing fills.
- B. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
- C. Place and compact fill material in layers to required elevations as follows:
 1. Under grass and planted areas, use satisfactory soil material, and a topsoil layer in accordance with the approved sediment and erosion control drawings.
 2. Under walks and pavements, use satisfactory soil material, or engineered fill.
 3. Under steps and ramps, use satisfactory soil material, or engineered fill.
 4. Under building slabs, use satisfactory soil material, or engineered fill.
 5. Under footings and foundations, use satisfactory soil material or engineered fill.

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. Remove and replace, or scarify and air-dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.15 COMPACTION OF BACKFILLS AND FILLS

- 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 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, and uniformly along the full length of each structure.
- C. Compact soil to not less than the following percentages of maximum dry density according to ASTM D 698:
 - 1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill material to at least 95 percent of maximum dry density.
 - 2. Under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill material to at least 95 percent of maximum dry density.
 - 3. Under lawn or unpaved areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill material at 90 percent of maximum dry density.
 - 4. Backfill against exterior walls shall consist of flowable fill to within 12 inches of exterior grade.

3.16 GRADING

- A. General: Uniformly grade areas to a smooth surface, free from irregular surface changes. Comply with compaction requirements and grade to contours, spot elevations, cross sections, and lines indicated.
 - 1. Provide a smooth transition between adjacent existing grades and new grades.
 - 2. Cut out soft spots, fill low spots, and trim high spots to comply with 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 inch. (Subgrade shall be a minimum of 4" below finished grade to allow for topsoil.)
 - 2. Walks: Plus or minus 1/2 inch.
 - 3. Pavements: Plus or minus 1/2 inch.
- C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

3.17 SUBSURFACE DRAINAGE

- A. Drainage Piping: Drainage pipe is specified in Division 33 Section "Subdrainage."
- B. Subsurface Drain: Place a layer of drainage fabric around perimeter of drainage trench as indicated. Place a 6-inch course of filter material on drainage fabric to support drainage pipe. Encase drainage pipe in a minimum of 12 inches of filter material and wrap in drainage fabric, overlapping sides and ends at least 6 inches.
 - 1. Compact each course of filter material to at least 95 percent of maximum dry density according to ASTM D 698.

- C. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches of final subgrade. Overlay drainage backfill with one layer of drainage fabric, overlapping sides and ends at least 6 inches.
 - 1. Compact each course of filter material to 95 percent of maximum dry density according to ASTM D 698.
 - 2. Place and compact impervious fill material over drainage backfill to final subgrade.

3.18 DRAINAGE COURSE

- A. Under slabs-on-grade, install drainage fabric on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends. Place drainage course on drainage fabric and as follows:
- B. Under slabs-on-grade, place drainage course on prepared subgrade and as follows:
 - 1. Compact drainage course to required cross sections and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 698.
 - 2. When compacted thickness of drainage course is 6 inches or less, place materials in a single layer.
 - 3. When compacted thickness of drainage course exceeds 6 inches, place materials in equal layers, with no layer more than 6 inches thick or less than 3 inches thick when compacted.

3.19 PREPARATION OF SUBGRADE

- A. All surfaces shall be to the prescribed subgrades, in an even and properly compacted condition. All mounds, ridges, gullies and depressions shall be removed and other necessary repairs performed.
- B. Tillage: After the areas to be topsoiled have been improved for proper subgrade, the surface shall be loosened and made friable by cross-discing or other satisfactory methods, to a depth of at least 2 inches to permit bonding of topsoil to the subgrade. All stones and debris 1 inch or more in any dimension shall be removed from the surface of the subgrade. Soil amendments shall be incorporated as listed on the approved Sediment and Erosion Control drawings.

3.20 PLACING TOPSOIL

- A. Topsoil shall not be placed when either the subgrade or the topsoil is wet or frozen enough to cause clodding.
- B. Topsoil shall be placed to a minimum depth of 4 inches or depth as noted over areas shown on the Drawings.
- C. The finished surface of the topsoiled area shall have a vertical tolerance of +/- 0.1 foot.
- D. Equipment and methods for placing topsoil shall be such as to avoid mixing with subsoil.
- E. Stabilize all disturbed areas for lawn establishment in accordance with the approved Sediment and Erosion Control drawings.

3.21 EXCESS TOPSOIL AND RESTORATION OF STOCKPILE AREAS

- A. All unsatisfactory and excess topsoil shall be removed from the site by the Contractor, unless approved otherwise by the Owner's Representative.
- B. All areas preciously occupied by stockpiled topsoil shall be restored in accordance with the Permanent Seeding "notes" or paving as shown on the approved Sediment and Erosion Control drawings.

3.22 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent geotechnical engineering testing agency to perform field quality-control testing.
- B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.
- C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Owner's Representative.
- D. Testing agency will 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:
 - 1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft. or less of paved area or building slab, but in no case fewer than three tests.
 - 2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for each 100 feet or less of wall length, but no fewer than two tests.
 - 3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for each 150 feet or less of trench length, but no fewer than two tests.
- E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required; recompact and retest until specified compaction is obtained.

3.23 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
 - 1. Scarify or remove and replace soil material to depth as directed by Owner's Representative; reshape and recompact.

- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil 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.

3.24 DISPOSAL OF EXCESS AND WASTE MATERIALS

- A. Disposal: Remove excess satisfactory soil and topsoil, waste material, unsatisfactory soil, excess topsoil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION 31 20 00

SECTION 31 20 02 – BIORETENTION SOIL

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. Furnishing and installation of Planting Soil within all Micro-bioretenion Facilities.

1.3 DEFINITIONS

- A. Planting Soil: Soil, of a variety of textures, defined in this section, intended to fill the Micro-bioretenion Facilities and other planting spaces to support the growth of trees and other plants.
- B. Soil Peds: Clumps of soil that naturally aggregate during the soil building process. Creating a soil mix shall be done in a way that maintains the soil peds. Refrain from over-mixing.
- C. Tree: A perennial woody plant with one or several trunks and a distinct crown and intended to become large enough to shade people and or vehicles.

1.4 SUBMITTALS

- A. Upon forty-five (45) days prior to start of installation of items in this section, the Contractor shall provide submittals required in this section to the landscape architect for review and approval.
- B. Product Data: For each type of product, submit manufacture's product literature with technical data sufficient to demonstrate that the product meets the requirements of the specification.
- C. Material Certificates: Submit material certificates for all natural and bulk material indicating that the material meets the requirements of the specification.
- D. Soil test analysis: Submit soil testing results from an approved soil-testing laboratory for each soil and soil mix for approval.
 - 1. All testing will be at the expense of the Contractor. The landscape architect may request additional planting mix tests on different mix component ratios in order to attain results that more closely meet the mix requirements.
 - 2. The testing laboratory shall be a member of the Soil Science Society of America's, North American Proficiency Testing Program (NAPT), and have a minimum of five years experience with the test protocols of the United States Golf Association - Green Section.

3. All testing shall comply with the requirements of the Methods of Soil Analysis Part 1 and 3, published by the Soil Science Society of America.
4. Soil testing shall be as required for each product and as defined below:

- a. Physical analysis.

- 1) Particle size analysis shall be provided for gravel, clay, silt, and sand fraction
- 2) USDA soil texture

- b. Chemical analysis. Note that nutrient levels and chemical analysis shall include recommendations from the testing laboratory for ranges of each element appropriate for the types of plants to be grown in the soil mix

- 1) Nutrient levels by parts per million including phosphorus, potassium, and magnesium
- 2) Percent organic content (ASTM 2974)
- 3) pH
- 4) Soluble salt by electrical conductivity

- E. Samples for Verification: Submit two gallon samples of each product and material where required by the specification to the landscape architect for approval. Label samples to indicate product, source location, specification number, characteristics, and locations in the Work. Samples will be reviewed for appearance only. Compliance with all other requirements is the exclusive responsibility of the contractor. Delivered materials shall closely match the samples.

1. Planting soil shall be labeled as to the percentage of each component in the mix.

1.5 SCHEDULING

- A. General: Prior to the start of Work, prepare a detailed schedule of the work for coordination with other trades.
- B. Schedule all utility installations prior to beginning work in this section.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Soil within the Micro-bioretenion Facilities shall be installed by the same contractor that is constructing the facility.

1.7 PERMITS AND CODE COMPLIANCE

- A. Comply with applicable requirements of the laws, codes, ordinances and regulations of Federal, State and Municipal authorities having jurisdiction. Obtain necessary permits/approvals from all such authorities.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, if applicable. Protect materials from deterioration during delivery and while on the project site.
- B. Bulk Materials: Do not deliver or place backfill, soils and soil amendments in frozen, wet, or muddy conditions.
 - 1. Bulk materials shall be stored and staged in a location approved by landscape architect or as indicated on the plans and in a manner that prevents damage to the site or the stored materials.
 - 2. Provide protection including tarps, plastic and or matting between all bulk materials and any finished surfaces sufficient to protect the finish material.
- C. Provide erosion-control measures to prevent erosion or displacement of bulk materials and discharge of soil-bearing water runoff or airborne dust to adjacent properties, water conveyance systems, and walkways. Provide additional sediment control to retain excavated material, backfill, soil amendments and planting mix within the project limits as needed.
- D. Bulk material shall be stored and staged in a location approved by landscape architect or as indicated on the plans and in a manner that prevents damage to the site or the stored materials.

1.9 PROJECT CONDITIONS

- A. Weather Limitations: Do not proceed with work when subgrades, soils and planting soils are in a wet, muddy or frozen condition.

1.10 PROJECT WORK

- A. Coordinate installation with all other work that may impact the completion of the Micro-bioretenion Facilities installation.

PART 2 - PRODUCTS

2.1 PLANTING SOIL -BIORETENTION SOIL MIX (for stormwater applications)

- A. Planting mix of compost and coarse sand mixed to the following proportion. Where soil is classified by USDA Soil Textural Classification, the particle size of sand is 2.0 mm to 0.05 mm, silt is 0.05 mm to 0.002 mm, and clay is less than 0.002 mm. Clay content must not exceed 5%.

Material	% by volume
Loamy Sand	60-65%
Compost	35-40%
Or	
Sandy Loam	30%
Coarse Sand	30%

Compost 40%

B. Chemical Requirements for Bioretention Material

Parameter	Units	Acceptable Range
Organic Matter	% Dry Weight	10% min
pH	pH Units	5.5 to 7.0
Soluble Salt	ppm	500 or less
Magnesium	lb/ac	35
Phosphorus (phosphate - P ₂ O ₅)	lb/ac	75
Potassium (potash - K ₂ O)	lb/ac	85

C. Planting mix shall be thoroughly mixed prior to installation.

D. Submit two gallon sample for approval by the Landscape Architect.

END OF SECTION 31 20 02

SECTION 31 31 16 – TERMITE CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The drawings and provisions of the General conditions, Special Conditions, and Division 01, Specification Sections, apply to the work of this section.

1.2 SCOPE OF WORK

- A. The Contractor is responsible for providing a continuous soil treatment barrier to protect each building against attack by subterranean termites. Applications of termiticide shall be in conformance with the label directions of the termiticide(s) used, and as further specified in paragraph B, below, and in Part 3-Execution.
- B. The Contractor shall provide soil treatments for subterranean insects around the exterior of all perimeter foundation walls and the interior of foundation walls in crawlspaces by soil trenching or by soil trenching and rodding (not rodding alone). The Contractor shall treat under existing interior slabs that are scheduled to remain using subslab injection or by horizontal rodding. The Contractor shall treat along both sides of all interior load bearing walls, along all cracks and expansion joints, and, if necessary, on one side of interior non-bearing walls. All critical areas shall be treated as per label instructions. Critical areas include locations where the foundation is penetrated by utility services, any cracks and expansion joints, bath traps, and areas where cement constructions have been or are to be poured adjacent to the foundation. Where new interior and exterior concrete slabs, walkways or areaways are to be constructed, the soil shall be treated with a coarse, low-pressure spray of a termiticide as per the label instructions for pre-construction subterranean termite treatment.
- C. Termite treatments shall be coordinated with construction schedules and activities. Exterior perimeter termite treatments shall occur after installation of foundation waterproofing, the completion of the finished grade, and any activity that may disturb the termiticide barrier, and before the installation of ramps, slabs, and other finished concrete or masonry at the building perimeters. Treatment of new slabs shall be done as a “pre-construction treatment” before the slabs are constructed. Existing slabs shall be treated before the finished floor is installed.
- D. Unless otherwise approved, drilling of finished flooring, newly poured concrete slabs, walkways, and areaways is prohibited, as is drilling into waterproofed foundation walls.
- E. The Contractor shall coordinate the execution of the various termite treatments with the General Contractor at the appropriate point(s) in the project schedule.

1.3 RELATED WORK DESCRIBED ELSEWHERE

- A. Division 06 Section “Rough Carpentry” for wood preservative by pressure process
- B. Division 05 Section “Sheet Metal Flashing and Trim” for custom-fabricated, metal termite shields

1.4 QUALITY ASSURANCE

- A. Applicator shall comply with all related requirements associated with:
 - 1. Federal Insecticide, Fungicide and Rodenticide Act
 - 2. Occupational Safety and Health Act, and applicable OSHA regulations, in particular OSHA's Hazard Communication Standard.
 - 3. Material packaging and handling requirements
 - 4. Maryland Pesticide Applicators Law and all associated regulations.
- B. Use and periodic re-calibration of an approved volumetric flow meter is required for all termiticide applications.
- C. Use of dye markers is required in the treatment of all soil.
- D. All termiticides are to be delivered to site with manufacturer's labels and seals intact and identifying container contents. Premixing of chemicals off site is prohibited.
- E. Contractor shall confirm through the General Contractor the existence and location of any new or existing foundation drainage system and the depth of any such system below finished grade.

1.5 SUBMITTALS

- A. Provide separate worksheets with estimates of the amount of termiticide to be used at each building. Show detailed calculations based on linear feet of treatment, depth of footers, areas to be treated, and application rates.
- B. Provide written confirmation from the General Contractor concerning the depth of footers.
- C. Provide written confirmation from the General Contractor concerning the non-existence or existence, location and depth below finished grade of any foundation drainage systems.
- D. Submit certificates of insurance for worker's compensation and liability insurance for bodily injury and property damage.
- E. Submit for Owner's review and approval manufacturer's specimen label and material safety data sheet for termiticide(s) and dye marker(s) to be used at each building.
- F. Submit records of each treatment procedure to include the following:
 - 1. Date and time.
 - 2. Weather conditions.
 - 3. Description of soil (type, temperature, moisture, etc.).
 - 4. Site diagrams of application.
 - 5. Methods of application and equipment used.
 - 6. Rate and volume applied at each site.
 - 7. Diary of volumetric flow meter readings in each site.
 - 8. Any problems identified.
 - 9. Names and qualifications of technicians and certified applicators performing each application.
 - 10. Other pertinent information.

11. Include a specimen label and material safety data sheet for any termiticide(s) and dye marker(s) used.

1.6 WARRANTY

- A. Provide a five-year-warranty for material and installation as indicated in Division 01, "Contract Closeout and Warranty."
- B. Warranty shall cover against invasion or propagation of subterranean termites, damage to building or building contents caused by termites, and repairs to building or building contents so caused.
- C. The Contractor shall inspect the property annually for five years to check for termite activity and conditions conducive to termite infestation, and provide each year written documentation of findings to the Department of Residential Facilities, Urban Biology Section Manager, 1205 Leonardtown Service Building, College Park, MD 20742.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Termiticide: The termite control subcontractor shall utilize any product registered by the State of Maryland for use as a soil termiticide AND containing one or more of the following active ingredients:
 1. Fiproni
 2. Imidacloprid
 3. Permethrin
 4. Cypermethrin
 5. Bifenthrin
 6. Chlorfenapyr
 7. Deltamethrin
 8. Lambda-cyhalothrin
- B. Visual Marker: Synthetic dye, unstable in ultraviolet light, as tank mix adjuvant to permit visual identification of treated soil.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Contractor is responsible for determining that conditions on site are acceptable before beginning termite treatment. Contractor shall verify that the soil surfaces are unfrozen, sufficiently dry to absorb toxicant, and ready to receive treatment. Exterior treatments shall not be permitted while precipitation is occurring, or under any other conditions where runoff or movement from the area is likely to occur. Notify Owner at least 2 weekdays in advance of all

interior and exterior treatments. All treatments must be performed in the presence of a University representative.

- B. Re-calibrate flow meter using a five-gallon test in the presence of a University representative prior to each tank mixing and following any adjustment of pressure regulator equaling 20 psi or more.
- C. All tank mixing shall be performed on site and in the presence of a University representative. All termiticide concentrate containers will bear an intact manufacturer's seal. Off site mixing/dilution of termiticide concentrate is prohibited.
- D. Contractor shall insure all debris, tools, construction materials, and non-essential cellulose containing form boards are cleared from soil at area to be treated and that soil conditions are satisfactory for the specific applications.
- E. Contractor shall insure that all construction workers and others leave the area to be treated during application and until the termiticide is absorbed into the soil.
- F. Beginning of application means Contractor's acceptance of all environmental conditions.

3.2 APPLICATION

- A. Apply termiticide in accordance with the termiticide manufacturer's instructions contained on the label and supplemental labeling, and at the manufacturer's recommended label rate.
- B. The Contractor must follow the necessary precautions to avoid exposing people to termiticide residues or vapors. Students, pedestrians, and others who may be nearby during treatment when soil is sprayed must be protected from drift by buffer zones and good application practices. Prior to each application, the Contractor must notify the construction superintendent or other responsible party of the termiticide application and the intended sites of application. The Contractor shall instruct the responsible party to notify construction workers and other individuals to leave the immediate treatment area during the application and until the termiticide is absorbed into the soil.
- C. Where new slabs are to be poured, apply a subslab termite treatment according to the instructions for pre-construction termiticide treatment and do so approximately 12 hours prior to installation of the vapor barrier.
- D. Treatment of the exterior building foundation shall be done by trenching alone, or by both trenching and rodding, but not by rodding alone unless trenching is impossible because of construction elements. Trench along the entire exterior perimeter of the building's foundation. Trenches shall be four to six inches wide and a minimum of six inches deep. Rod holes must be spaced so as to achieve a continuous chemical barrier but in no case more than 12 inches apart. Refill the trench, treating the soil thoroughly with termiticide as soil is replaced.
- E. At the building exterior, apply toxicant after finish grading, compaction, and any waterproofing of outside foundation walls has been accomplished and prior to installation of new concrete ramps, sidewalks and areaways. The Contractor shall not drill into new exterior concrete or masonry walls, ramps, sidewalks and areaways, or into any walls covered with waterproofing material. Coordinate soil treatment at foundation perimeter with finish grading, concrete, and other perimeter work to avoid disturbance of treated soil and newly installed concrete surfaces.

- F. The treatment of the building's interior shall include trenching and rodding or trenching of any crawlspace foundation walls, load bearing walls, pillars, and other foundation elements and subslab injections or horizontal rodding of any original flood slabs scheduled to remain using the specified termiticide. Where applicable, injections shall be made no more than 12" apart along the entire interior perimeter of the building, along both sides of interior load bearing walls, around utility penetrations, along all cracks and expansion joints and, if necessary, along one side of non-bearing partition walls.
- G. Where utility trenches are established in existing slabs, trenches shall be treated after utilities are installed and before new concrete cover is poured.
- H. Where new concrete floor slabs are required, interior treatment shall entail a trenched or trenched and rodded vertical barrier inside all foundation walls and along both sides of all interior load bearing walls and around piers and columns as well as a horizontal surface barrier using a coarse, low pressure spray (less than 50 psi) of sufficient termiticide to insure complete and proper coverage of the sub-soil. If the top of the footing is exposed during trenching, treat the soil adjacent to the footing to a depth not to exceed the bottom of the footing.
- I. Trenching and rodding requirements for the interior treatment shall be the same as those specified in Paragraph 3.2, Item D. above.
- J. Treatment of the building interior shall be completed prior to installation of finish flooring so that no finished floors shall be drilled. Exterior building treatments shall be coordinated to occur prior to installation of concrete areaways, ramps, and sidewalks.
- K. Where new or existing sump pumps or trench drains are installed, Contractor shall not contaminate the drains, subsurface water, or adjacent water with termiticide. Depending on conditions, it may be necessary to limit treatment in these areas to the treated backfill technique.

3.3 RETREATMENT

- A. Treated soil disturbed by construction or other activities shall be retreated with a chemical soil treatment using good industry practices and according to the directions on the termiticide label.
- B. If inspection by the Contractor or by the University identifies the presence of termites, the Contractor will retreat the soil in and around the infested area using good industry practices and according to the directions on the termiticide label.
- C. Use an appropriate termiticide listed in Paragraph 2.1, Materials, above.

END OF SECTION 31 31 16

SECTION 31 37 00 - SEDIMENT AND EROSION 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. This section includes the following:
 - 1. Measures to prevent erosion and runoff of earth and related materials.
 - 2. Methods to prevent the transport of sediment off-site by construction vehicles.
 - 3. Air quality and dust control.
- B. Related work in other sections
 - 1. Division 01 Section "Tree Protection & Trimming"
 - 2. Division 31 Section "Site Clearing"
 - 3. Division 31 Section "Earthwork"

1.3 REFERENCES AND QUALITY ASSURANCE

- A. "2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control," published jointly by the Maryland Department of the Environment, Water Management Administration in association with Soil Conservation Service and State Soil Conservation Committee.
- B. Baltimore County, Department of Public Works (BCDPW) Standard Specifications for Construction and Materials, 2010, as amended to date. Delete references to "Measurement and Payment".
- C. Baltimore County Department of Environmental Protection and Sustainability requirements in accordance with Title 14, Article IV and the "Guidelines to the Air Pollution Regulations for Controlling Excessive ABP (Dust on Activity Sites)"
- D. Contractor shall possess a Certificate of Attendance from the State of Maryland Department of Natural Resources and/or Maryland Department of the Environment training program for the control of sediment and erosion.

PART 2 - PRODUCTS

2.1 EROSION CONTROL MATERIALS

- A. As noted on the Drawings and as specified in REFERENCES AND QUALITY ASSURANCE above.

PART 3 - EXECUTION

3.1 NOTIFICATION

- A. Notify Baltimore County, Department of Public Works, and Owner's Representative 72 hours prior to start of Work.

3.2 GRADING

- A. Initial demolition and disturbance is limited to that necessary to gain access to site and install sediment control devices in accordance with Sequence of Operations as shown on the approved drawings. Sediment control devices shall be installed prior to beginning the new construction.
- B. Accomplish work so existing surface drainage is not impaired, a potential hazard is not created, hazardous erosion will not occur and sediment will not collect in existing drainage systems.

3.3 DRAINAGE CONTROL

- A. Control drainage before it causes erosion, if feasible, or direct into stable areas at non-erosive velocities consistent with established practices for erosion control.
- B. Provide additional measures to control velocities and prevent erosion in the field as directed by the Baltimore County Inspector. Payment shall be made in accordance with the Contract provisions affecting changes in the Work.

3.4 DUST CONTROL

- A. Provide water or approved techniques to reduce airborne dust when directed by the Inspector, at no additional cost to the Owner.

3.5 DAILY INSPECTION

- A. Inspect, maintain and repair, as necessary, all sediment control devices at end of each day and after each rainfall to insure that the devices are functional.

3.6 PERMANENT STABILIZATION AND FINAL RESTORATION

- A. Unless otherwise noted on Drawings, remove sediment control devices at end of project. Stabilize all remaining disturbed areas and areas occupied by devices in accordance with permanent stabilization notes on the approved drawings.
- B. Excess and remaining soil, stone and erosion control materials are the property of the Contractor. Remove from the site at no additional cost to Owner.

END OF SECTION 31 37 00

SECTION 31 66 13 - AGGREGATE PIER SOIL REINFORCEMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Sections Includes:

1. Aggregate Pier Design, Excavation, and Construction.

1.2 REFERENCES

A. Reference Standards: In addition to requirements shown or specified, comply with applicable provisions of following for design, materials, fabrication, and installation of component parts:

1. Design

- a. Lawton, E.C., N.S. Fox, and R.L. Handy. "Control of Settlement and Uplift of Structures Using Short Aggregate Piers." ASCE. Proceedings of In Situ Deep Soil Improvement. ASCE National Convention, Atlanta, Georgia. October 9 13, 1994.
- b. Lawton, E.C. and N.S. Fox. "Settlement of Structures Supported on Marginal or Inadequate Soils Stiffened with Short Aggregate Piers." ASCE. Geotechnical Special Publication No. 40: Vertical and Horizontal Deformations of Foundations and Embankments, ASCE 2, 962 974.
- c. Fox, N.S. and M. Cowell. 1998. Geopier Reference Manual. Published by Geopier Foundation Company, Inc., Scottsdale, AZ.
- d. Wissmann, K.J., E.C. Lawton, and T.M. Farrell. 1999. "Behavior of Geopier Supported Foundation Systems During Seismic Events." Technical Bulletin No. 1. Geopier Foundation Company, Inc., Scottsdale, AZ.
- e. Wissmann, K.J. 1999. "Bearing Capacity of Geopier Supported Foundation Systems." Technical Bulletin No. 2. Geopier Foundation Company, Inc., Scottsdale, AZ.
- f. Wissmann, K.J., J.M. Caskey, and B.T. Fitzpatrick. 2001. "Geopier® Uplift Resistance." Technical Bulletin No. 3. Geopier Foundation Company, Inc., Scottsdale, AZ.
- g. Wissmann, K.J., B.T. Fitzpatrick, and E.C. Lawton. 2001. "Geopier® Lateral Resistance." Technical Bulletin No. 4. Geopier Foundation Company, Inc., Scottsdale, AZ.
- h. Fitzpatrick, B.T. and K.J. Wissmann. 2002. "Geopier® Shear Reinforcement for Global Stability and Slope Stability." Technical Bulletin No. 5. Geopier Foundation Company, Inc., Scottsdale, AZ.

2. Modulus and Uplift Testing:

- a. ASTM D-1143 - Pile Load Test Procedures
- b. ASTM D-1194 - Spread Footing Load Test

3. Materials and Inspection:

- a. ASTM D-1241 - Aggregate Quality
- b. ASTM STP 399 - Dynamic Penetrometer Testing
- c. ASTM D-422 - Gradation Soils

B. Where specifications and reference documents conflict, the Architect/Engineer shall make the final determination of the applicable document.

1.3 SYSTEM DESCRIPTION

A. Aggregate Pier: constructed by compacting aggregate in an excavated hole using special high-energy impact densification equipment. The aggregate pier elements shall be in a columnar type configuration and shall be used to reinforce soils for the support of high bearing pressure spread footings.

B. Design Requirements:

- 1. Responsible for designing system, including anchorage to foundation for uplift and necessary modifications to meet specified requirements.
- 2. Employ registered professional engineer, licensed to practice structural engineering in jurisdiction where Project is located with minimum of five years experience, to engineer each component of the aggregate pier system.

C. Aggregate Pier Design Requirements:

- 1. Aggregate Pier stiffness modulus of 200 pci. The stiffness modulus value shall be verified by the results of the Aggregate Pier modulus test, described in this specification.
- 2. Design in accordance with generally-accepted engineering practice and the methods described in the referenced design standards.
- 3. The design shall meet the following criteria.

Minimum Allowable Bearing Pressure for Aggregate Pier Reinforced Soils	5000 psf
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Minimum Aggregate Pier Area Coverage (for square Spread Footings)	30%
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Estimated Total Long-Term Settlement for Footings:	< 1 inch
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Estimated Long-Term Differential Settlement of Adjacent Footings:	< 1/2 inch
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- 4. The design shall consider the bearing capacity and settlement of all footings supported by aggregate piers.
- 5. Total and differential settlement shall be considered.
- 6. Design life of the structure shall be 200 years. Aggregate pier tie down hardware shall be designed to withstand the below grade corrosive environment for this minimum length of time while maintaining the capacity to withstand the design uplift forces as indicated on the drawings.

7. System shall be designed to preclude plastic bulging deformations at the top-of-pier design stress and to preclude significant tip stresses as determined from the shape of the telltale test curve from telltales installed in modulus test piers. The results of the modulus test shall be used to verify the design assumptions.

D. Interface With Adjacent Systems:

1. Contractor shall coordinate all excavations made subsequent to Aggregate Pier installations so that at least five feet of horizontal distance remains between the edge of any installed Aggregate Pier and the excavation.
2. In the event that utility excavations are required at horizontal distances of less than five feet from installed Aggregate Piers, the General Contractor shall contact the Aggregate Pier Designer to develop construction solutions to minimize impacts on the installed Aggregate Piers.

1.4 SUBMITTALS

- A. Equipment Description: Manufacturer's data describing the drilling and high-energy impact densification equipment to be utilized.

B. Shop Drawings:

1. Pier layout plan: Provide plan referenced to the grid lines including a numbering system identifying each individual pier.
 - a. Identify minimum footing size, bottom of footing elevation, and aggregate pier locations, diameters and lengths.
 - b. Identify locations of any uplift anchor hardware where required including installation requirements.
 - c. Include criteria for excavations occurring after installation of the aggregate piers.
 - d. Include any footing construction criteria as it relates to performance of aggregate piers.
2. Stamp with seal and signature of professional engineer responsible for design.

C. Modulus Test Data:

1. Provide a report of test data verifying aggregate pier design parameters.
2. Stamp with seal and signature of professional engineer responsible for design.

D. Informational Submittals: Submit following packaged separately from other submittals:

1. Calculations: Submit for aggregate pier design in accordance with Section 01 33 00.
 - a. Calculations: Prepared by and bear seal and signature of registered professional engineer.
 - b. Include a detailed explanation of the design parameters for settlement calculations.
 - c. Include design loads, footing sizes and footing stresses.
 - d. Include design of any uplift anchor hardware required.
 - e. Identify any conditions where the required footing size or resulting footing stress exceeds those defined on the drawings.

2. Quality Control test program for aggregate piers, meeting design requirements.
 3. Test Reports: Submit following:
 - a. Written results of testing specified as part of Source and Field Quality Control articles.
 4. Certifications specified in Quality Assurance article.
 5. Qualification Data: engineer's and installer's qualification data.
 6. Daily Aggregate, Pier Progress Reports: a complete and accurate record of aggregate pier installation
 - a. Indicate the pier location, length, average lift thickness and final elevations of the base and top of piers.
 - b. Indicate the type and size of the densification equipment used.
- E. Closeout Submittals
1. Project Record Documents: Record actual locations of aggregate piers.

1.5 QUALITY ASSURANCE

- A. Engineer Qualifications: Registered professional engineer licensed to practice structural engineering in jurisdiction where Project is located, with minimum of five years experience in design of aggregate piers.
- B. Installer Qualifications: A minimum of 5 years of experience with the installation of aggregate piers and have completed at least fifty projects.
 1. Installers shall be licensed by Geopier Foundation Company, Inc.
 2. The Aggregate Pier Designer shall have Errors and Omissions design insurance for the work. The insurance policy should provide a minimum coverage of \$2 million per occurrence.
- C. Welder Qualifications: AWS certified within past 12 months for each type of weld required.
- D. Regulatory Requirements: Ensure flammable components comply with applicable portions of local, state, and federal codes, laws, and ordinances for flame spread and smoke developed indices.
- E. Certifications:
 1. Certificates verifying AWS qualifications for each welder employed on Project.
 2. Installer certification that installation meets or exceed specified requirements.
 3. Engineering Certifications.

1.6 PRE-INSTALLATION CONFERENCE

- A. Conduct pre-installation conference in accordance with Section 01 31 20.

- B. Attendance Required: Architect/Engineer, Contractor, Installer, and Geotechnical Consultant.
- C. Agenda: Discuss and agree upon geotechnical requirements, preparatory work, and methods of installation and record keeping.

1.7 PROJECT CONDITIONS

- A. A geotechnical report has been prepared for this Project and is provided for information only as part of the Project Manual. The report is not part of the Contract Documents. Owner will not be responsible for interpretations or conclusions drawn from the data by Contractor.
- B. Existing Conditions: Field verify existing conditions prior to commencing work of this Section.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Aggregate: for piers constructed above the water table
 1. Type I Grade B or Grade C in accordance with ASTM D 1241 68, or shall be other graded aggregate selected by the Installer and successfully used in the modulus test.
 2. It shall be compacted to a densification and strength, which provides resistance to the, dynamic penetration test (ASTM STP 399) of a minimum average of 15 blows per 1.75 inch vertical movement.
- B. Water: Fresh, clean, and potable shall be used to increase aggregate moisture content where required.
- C. Uplift Anchor Hardware: Selected by Aggregate Pier Designer as required to meet project requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. General: Examine conditions and proceed with work in accordance with Section 01 40 00.
- B. Site Verification of Conditions: Verify existing conditions prior to commencing drilling operations.

3.2 PREPARATION

- A. Use placement methods that will not cause damage to nearby structures.
- B. Notify adjacent and affected land owners and building occupants before proceeding with work.

- C. Protect structures and utilities near the work from damage.

3.3 MODULUS TEST

- A. The contractor shall provide complete testing materials and equipment.
- B. A modulus test shall be performed to verify the parameter values selected for design.
- C. The modulus tests shall be of the type and installed in a manner specified herein.
 - 1. A telltale shall be installed at the bottom of the test pier so that bottom-of pier deflections may be determined.
 - 2. Acceptable performance is indicated when the bottom of the pier deflection is no more than 20% of the top of pier deflection at the design stress level.
 - 3. ASTM D 1143 general test procedures shall be used as a guide to establishing load increments, load increment duration, and load decrements.
 - 4. With the exception of the load increment representing approximately 115% of the design maximum top of Aggregate Pier stress, all load increments shall be held for a minimum of 15 minutes, a maximum of 1 hour, and until the rate of deflection reduces to 0.01 inch per hour, or less.
 - 5. The load increment that represents approximately 115% of the design maximum stress on the Aggregate Pier shall be held for a minimum of 15 minutes, a maximum of 4 hours and until the rate of deflection reduces to 0.01 inches per hour or less.
 - 6. A seating load equal to 5 percent of the total load shall be applied to the loaded steel plate prior to application of load increments and prior to measurement of deflections to compensate for surficial disturbance.
 - 7. The location of the aggregate pier modulus test should be coordinated with the project Geotechnical Engineer of record.

3.4 APPROVED INSTALLATION PROCEDURES

- A. The following sections provide general criteria for the construction of the Rammed Aggregate Pier elements. Unless otherwise approved by the Designer, the installation method used for pier construction shall be that as used in the construction of the successful modulus test.
- B. Augered RAP Systems:
 - 1. Pre-augered using mechanical drilling or excavation equipment.
 - 2. If cave-ins exceeding 10 percent of lift volume occur during excavation such that sidewalls of the hole are deemed to be unstable, use steel casing to stabilize the cavity or use displacement RAP system.
 - 3. Place aggregate in saugered cavity in lift thickness as determined by shop drawings.
 - 4. Use specialty-designed beveled tamper and high-energy impact densification apparatus to denisfy lifts of aggregate during installation.
 - 5. Do not use compaction equipment that induces horizontal vibratory energy (such as Vibroflot equipment).
- C. Plan Location and Elevation of RAP Elements:
 - 1. Submit as-built center of each pier located within 6 inches of locations indicated on the shop drawings.

2. Rebuild RAP installed outside of the above tolerances and deemed not acceptable at no additional expense to Owner.

D. Rejected RAP Elements

1. Abandon RAP elements installed beyond maximum allowable tolerances and replace with new RAP, unless the Engineer approved condition or provides other remedial measures.

E. Acceptable Installers:

1. Hayward Baker, Owings Mills, MD.
2. GeoStructures, Inc., Leesburg, VA
3. Accepted Substitute in accordance with Section 01 60 00.

3.5 DYNAMIC CONE PENETROMETER TEST

- A. The Aggregate Pier elements shall be tested by the Dynamic Cone Penetrometer method (ASTM STP 399) at locations within the upper 1/3 of the pier shaft length.
- B. The minimum acceptable criteria as an indicator of acceptable densification shall be at least 15 blows per 1 3/4 inch penetration.
- C. Dynamic Cone Penetrometer testing shall be performed in each Aggregate Pier until such time as five consecutive tests indicate that the minimum criterion is met. Thereafter, such tests need not be performed on every pier, provided that the aggregate used in the elements is representative of that previously tested. If average penetration resistances measured exceed 15 blows, and less than 10% of tests fall below 15 blows, then testing may be reduced to spot checks. A pattern of successful tests is sufficient to reduce testing to several tests per day.
- D. Observation of questionable aggregate moisture content or questionable aggregate gradation appearance may determine the need for additional dynamic penetration testing to verify that the proper densification is being achieved.
- E. Use of Dynamic Cone Penetrometer is not appropriate for use on open graded aggregate such as No. 57 stone.

3.6 CONSTRUCTION TOLERANCES

- A. Construct piers plumb and square while maintaining dimensional tolerances and alignment.
- B. Maximum Variation of Location: 6 inches.
- C. Top of Pier Elevation: Minus 2 inches.
 1. Defined as the lowest point on the aggregate in the last compacted lift.

3.7 FIELD QUALITY CONTROL

- A. Site Tests & Inspections: Comply with Section 01 40 00.
- B. Owner engage Independent Testing Laboratory approved by the Architect/Engineer. Laboratory shall be on job continuously during aggregate pier installation and testing.
- C. Perform modulus test to verify the parameter values selected for design.
- D. Test Reports: Prepare reports for each test
- E. The presence of the Independent Testing Laboratory does not relieve the Contractor of responsibility for deviations from Contractor Document requirements unless Architect/Engineer is informed in writing of deviations and approval is received in writing from Architect/Engineer for such deviations.
- F. Independent Testing Laboratory is responsible for the following:
 - 1. Witness and monitor Modulus test procedures.
 - 2. Monitor the installation of aggregate pier elements to verify that the production installation practices are similar to those used during the installation of the modulus test elements.
 - 3. Perform Dynamic Cone Penetrometer tests as described herein.
 - 4. Provide continuous inspection of aggregate pier installations. Submit reports documenting information for each pile as follows:
 - a. Footing and Aggregate Pier location.
 - b. Aggregate Pier length and drilled diameter.
 - c. Planned and actual Aggregate Pier elevations at the top and bottom of the element.
 - d. Average lift thickness for each Aggregate Pier.
 - e. Soil types encountered at the bottom of the Aggregate Pier and along the length of the element.
 - f. Depth to groundwater, if encountered.
 - g. Documentation of any unusual conditions encountered.
 - h. Type and size of densification equipment used.
 - 5. Submit reports; include site observations, instructions, and monitoring activities.

END OF SECTION 31 66 13

SECTION 32 12 16 - HOT-MIX ASPHALT PAVING

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 the following:
 - 1. Hot-mix asphalt paving.
 - 2. Hot-mix asphalt patching.
 - 3. Pavement-marking paint.
- B. Related Sections include the following:
 - 1. Division 31 Section "Earthwork" for aggregate subbase and base courses and for aggregate pavement shoulders.

1.3 DEFINITIONS

- A. Hot-Mix Asphalt Paving Terminology: Refer to ASTM D 8 for definitions of terms.

1.4 SYSTEM DESCRIPTION

- A. Provide hot-mix asphalt paving according to materials, workmanship, and other applicable requirements of standard specifications of the Baltimore County, Department of Public Works.
 - 1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.5 SUBMITTALS

- A. Job-Mix Designs: For each job mix proposed for the Work.
- B. Material Test Reports: For each paving material.

1.6 QUALITY ASSURANCE

- A. Material and installation Specifications: Baltimore County, Department of Public Works Specifications for Material, Highways, Bridges, Utilities, and Incidental Structures (BCDPW), 2010, as amended to date.

- B. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated, as documented according to ASTM E 548.
- C. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.
- B. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

1.8 PROJECT CONDITIONS

- A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp or if the following conditions are not met:
 - 1. Prime and Tack Coats: Minimum surface temperature of 60 deg F.
 - 2. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
 - 3. Asphalt Surface Course: Minimum surface temperature of 60 deg F at time of placement.
- B. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F for oil-based materials, 50 deg F for water-based materials, and not exceeding 95 deg F.

PART 2 - PRODUCTS

2.1 AGGREGATES

- A. General: Use materials and gradations that have performed satisfactorily in previous installations.
- B. Base Course: GA Base crushed stone in accordance with BCDPW Table 20.02-2 and Article 20.02.

2.2 ASPHALT MATERIALS

- A. Prime Coat: Asphalt emulsion prime complying with BCDPW Article 20.12.
- B. Tack Coat: AASHTO M 140, emulsified asphalt, of suitable grade and consistency for application complying with BCDPW Article 20.12.
- C. Water: Potable.

2.3 AUXILIARY MATERIALS

- A. Pavement-Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, with drying time of less than 45 minutes.
 - 1. Color: White for all applications except handicapped space symbol to be blue and white and fire lane curb red.

2.4 MIXES

- A. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes (HMA) in accordance with BCDPW Section 20.13 for bituminous concrete mixtures.
 - 1. Surface Course: Band 'SN' in accordance with BCDPW Section 20.13-4.
 - 2. Binder Course: Band 'BI' or 'BC' in accordance with BCDPW Section 20.13-4.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Contractor shall engage a geotechnical engineering testing agency to verify that subgrade is dry and in suitable condition to support paving and imposed loads.
- B. Proof-roll subbase using heavy, pneumatic-tired rollers to locate areas that are unstable or that require further compaction.
- C. Proceed with paving only after unsatisfactory conditions have been corrected.

3.2 PATCHING

- A. Hot-Mix Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.
- B. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting into new, hot-mix asphalt paving at a rate of 0.05 to 0.15 gal./sq. yd..
 - 1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
 - 2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.
- C. Patching: Partially fill excavated pavements with hot-mix asphalt base mix and, while still hot, compact. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.

3.3 SURFACE PREPARATION

- A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.
- B. Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of 0.15 to 0.50 gal./sq. yd.. Apply enough material to penetrate and seal but not flood surface.
- C. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.
 - 1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
 - 2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.4 HOT-MIX ASPHALT PLACING

- A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted. Installation shall be in accordance with BCDPW Article 33.07.
 - 1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
 - 2. Place hot-mix asphalt surface course in single lift.
 - 3. Spread mix at minimum temperature of 250 deg F.
 - 4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes, unless otherwise indicated.
 - 5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.
- B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.
 - 1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Complete a section of asphalt base course before placing asphalt surface course.
- C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.5 JOINTS

- A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions with same texture and smoothness as other sections of hot-mix asphalt course.

3.6 COMPACTION

- A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or vibratory-plate compactors in areas inaccessible to rollers.
 - 1. Complete compaction before mix temperature cools to 185 deg F.
- B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.
- C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:
 - 1. Average Density: 96 percent of reference laboratory density according to AASHTO T 245, but not less than 94 percent nor greater than 100 percent.
- D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.
- E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.
- F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface 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.

3.7 INSTALLATION TOLERANCES

- A. Thickness: Compact each course to produce the thickness indicated within the following tolerances:
 - 1. Base Course: Plus 1/2 inch, no minus.
 - 2. Surface Course: Plus 1/4 inch, no minus.
- B. Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
 - 1. Base Course: 1/4 inch.
 - 2. Surface Course: 1/8 inch.
 - 3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

3.8 PAVEMENT MARKING

- A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Baltimore County Representative.
- B. Allow paving to age for 15 days before starting pavement marking.
- C. Sweep and clean surface to eliminate loose material and dust.
- D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.
- E. Striping shall be applied
- F. Install handicapped parking markings and signage in accordance with the drawings and State of Maryland regulations.

3.9 TRAFFIC AND LANE MARKINGS

- A. Apply 2 coats of chlorinated rubber alkyd type traffic-lane marking paint (AASHTO M248) over clean paving surface. Layout and review with Architect and Baltimore County representative before painting application. Use yellow color for car parking in bus parking lot and white for all other applications.
- B. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.

3.10 WHEEL STOPS

- A. Securely attach wheel stops into pavement with not less than two galvanized steel dowels. Securely install dowels into pavement. Recess head of dowel 1/2" beneath top of wheel stop.

3.11 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and to prepare test reports.
 - 1. Testing agency will conduct and interpret tests and state in each report whether tested Work complies with or deviates from specified requirements.
- B. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- C. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.
- D. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

- E. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to AASHTO T 168.
- F. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
 - 1. One core sample will be taken for every 1000 sq. yd. or less of installed pavement, with no fewer than 3 cores taken.
 - 2. 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.
- G. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.12 DISPOSAL

- A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them.
 - 1. Do not allow excavated materials to accumulate on-site.

END OF SECTION 32 12 16

SECTION 32 13 13 - PORTLAND CEMENT CONCRETE PAVEMENT

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 cement concrete pavement for the following:
 - 1. Driveways and roadways.
 - 2. Curbs and gutters.
 - 3. Walkways.
 - 4. Miscellaneous slabs-on-grade and related items.
- B. Related Sections include the following:
 - 1. Division 31 Section "Earthwork" for subgrade preparation, grading, and subbase course.

1.3 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, and other pozzolans.

1.4 SUBMITTALS

- A. Product Data: For each type of manufactured material and product indicated.
- B. Design Mixes: For each concrete mix. Include alternate mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.
- C. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of current materials:
- D. Material Certificates: Signed by manufacturers certifying that each of the following materials complies with requirements:
 - 1. Cementitious materials and aggregates.
 - 2. Steel reinforcement and reinforcement accessories.
 - 3. Admixtures.
 - 4. Curing compounds.
 - 5. Applied finish materials.
 - 6. Bonding agent or adhesive.

7. Joint filler materials.
8. Joint sealants.

E. Minutes of preinstallation conference.

1.5 QUALITY ASSURANCE

- A. Material and Installation Specifications: Baltimore County, Department of Public Works (BCDPW) STANDARD SPECIFICATIONS AND DETAILS FOR CONSTRUCTION, latest edition as amended to date. Maryland Department of Transportation, State Highway Administration STANDARD SPECIFICATIONS FOR CONSTRUCTION (MSHA) October 2010 as amended to date.
- B. Installer Qualifications: An experienced installer who has completed pavement work similar in material, design, and extent to that indicated for this Project and who can demonstrate no less than a 5-year record of similar construction work that has resulted in successful in-service performance.
- C. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.
 1. Manufacturer must be certified according to the National Ready Mix Concrete Association's Plant Certification Program.
- D. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 to conduct the testing indicated, as documented according to ASTM E 548.
- E. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant and each aggregate from one source.
- F. ACI Publications: Comply with ACI 301, "Specification for Structural Concrete," unless modified by the requirements of the Contract Documents.
- G. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixes.
- H. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Meetings."
 1. Before submitting design mixes, review concrete mix design and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with concrete mix designs to attend, including the following:
 - a. Contractor's superintendent.
 - b. Concrete subcontractor.

1.6 PROJECT CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Products: Subject to compliance with requirements and approval of shop submittals by the Architect, products that may be incorporated into the Work are not specifically limited to those products that are specified hereafter in this section.

2.2 CRUSHED STONE AGGREGATE BASE COURSE

- A. Base Course: Graded Aggregate Base stone in accordance with BALTIMORE COUNTY DEPARTMENT OF PUBLIC WORKS (BCDPW) Table 20.02-2 and Article 20.02.

2.3 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 of 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.

2.4 STEEL REINFORCEMENT

- A. Plain-Steel Welded Wire Fabric: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.
- B. Deformed-Steel Welded Wire Fabric: ASTM A 497, flat sheet.
- C. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed.
- 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.
- F. Tie Bars: ASTM A 615/A 615M, Grade 60, deformed.
- G. Hook Bolts: ASTM A 307, Grade A, internally and externally threaded. Design hook-bolt joint assembly to hold coupling against pavement form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.
- H. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcement bars, welded wire fabric, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete or fiber-reinforced 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.

2.5 CONCRETE MATERIALS

- A. General: Use the same brand and type of cementitious material from the same manufacturer throughout the Project.
- B. Portland Cement: ASTM C 150, Type I or II. Ground granulated blast-furnace slag shall not be used in concrete mixes.
- C. Aggregate: ASTM C 33, uniformly graded, from a single source, with coarse aggregate in accordance with BCDPW specifications.
 1. Do not use fine or coarse aggregates containing substances that cause spalling.
- D. Water: ASTM C 94.

2.6 ADMIXTURES

- A. General: Admixtures certified by manufacturer to contain not more than 0.1 percent water-soluble chloride ions by mass of cement and to be compatible with other admixtures.
- B. Air-Entraining Admixture: ASTM C 260.
- C. Water-Reducing Admixture: ASTM C 494, Type A.
- D. High-Range, Water-Reducing Admixture: ASTM C 494, Type F.
- E. Water-Reducing and Accelerating Admixture: ASTM C 494, Type E.
- F. Water-Reducing and Retarding Admixture: ASTM C 494, Type D.

2.7 CURING MATERIALS

- A. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- B. Water: Potable.
- C. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.
- D. Clear Solvent-Borne Liquid-Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.
- E. Clear Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.

2.8 RELATED MATERIALS

- A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber, or ASTM D 1752, cork or self-expanding cork.
- B. Expansion Joint Cap: "Sealtight Snap-Cap", size to match expansion joint filler, as manufactured by the following, or approved equal:
- C. W.R. Meadows, Inc., PO Box 543, Elgin, IL 60121, (708) 683-4500
- D. Expansion Joint Sealant: "THC-900", color to match concrete (color selection subject to Owner approval) as manufactured by the following, or approved equal:
- E. TREMCO, 3735 Green Road, Beachwood, OH 44122, (800) 321-7900
- F. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

2.9 CONCRETE MIXES

- A. Prepare design mixes, proportioned according to ACI 211.1 and ACI 301, for each type and strength of normal-weight concrete determined by either laboratory trial mixes or field experience.
- B. Use a qualified independent testing agency for preparing and reporting proposed mix designs for the trial batch method.
 - 1. Do not use Owner's field quality-control testing agency as the independent testing agency.
- C. Portland Cement Concrete mixes shall be as indicated on the drawings and in accordance with BCDPW Specification Table 20.07-5 and Article 20.07.
- D. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having an air content as follows within a tolerance of plus or minus 1.5 percent:
 - 1. Air Content: 5.5 percent for 1-1/2-inch maximum aggregate.
 - 2. Air Content: 6.0 percent for 1-inch maximum aggregate.
 - 3. Air Content: 6.0 percent for 3/4-inch maximum aggregate.

2.10 CONCRETE MIXING

- A. Ready-Mixed Concrete: Comply with requirements and with ASTM C 94 and ASTM C 1116.
 - 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: Comply with requirements and measure, batch, and mix concrete materials and concrete according to ASTM C 94. Mix concrete materials in appropriate drum-type batch machine mixer.

1. For mixers of 1 cu. yd. or smaller capacity, continue mixing at least one and one-half minutes, but not more than five minutes after ingredients are in mixer, before any part of batch is released.
2. For mixers of capacity 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, mix type, mix time, quantity, and amount of water added.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Proof-roll prepared subgrade surface to check for unstable areas and verify need for additional compaction. Proceed with pavement only after nonconforming conditions have been corrected and subgrade is approved by the Geotechnical Engineer.
- B. Remove loose material from compacted subgrade surface immediately before placing crushed stone aggregate base course.
- C. Install base course as indicated on the drawings.

3.2 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for pavement to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
- B. Clean forms after each use and coat with form release agent to ensure separation from concrete without damage.

3.3 STEEL REINFORCEMENT

- A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating reinforcement and with recommendations in CRSI's "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. 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.
- E. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch overlap to adjacent mats.

3.4 JOINTS

- A. General: Construct construction, isolation, and contraction joints and tool edgings true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline, unless otherwise indicated.
 - 1. When joining existing pavement, place transverse joints to align with previously placed joints, unless otherwise indicated.
- B. Construction Joints: Set construction joints at side and end terminations of pavement and at locations where pavement operations are stopped for more than one-half hour, unless pavement terminates at isolation joints.
 - 1. Continue reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of pavement strips, unless otherwise indicated.
 - 2. Provide tie bars at sides of pavement strips where indicated.
 - 3. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
- C. Isolation 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. Locate expansion joints at intervals of 20 feet, unless otherwise indicated.
 - 2. Extend joint fillers full width and depth of joint.
 - 3. Terminate joint filler less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.
 - 4. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
 - 5. Protect top edge of joint filler during concrete placement with plastic temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.
- D. Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt-coat one-half of dowel length to prevent concrete bonding to one side of joint.
- E. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows:
 - 1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with groover tool to the following radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover marks on concrete surfaces.
 - a. Radius: 3/8 inch.
 - 2. Sawed Joints for Concrete Curb: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
- F. Edging: Tool edges of pavement, gutters, curbs, and joints in concrete after initial floating with an edging tool to the following radius. Repeat tooling of edges after applying surface finishes. Eliminate tool marks on concrete surfaces.

1. Radius: 3/8 inch.

3.5 CONCRETE PLACEMENT

- A. Inspection: Before placing concrete, inspect and complete formwork installation, reinforcement steel, and items to be embedded or cast in. Notify other trades to permit installation of their work.
- B. Remove snow, ice, or frost from subbase surface and reinforcement before placing concrete. Do not place concrete on frozen surfaces.
- C. Moisten subbase 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 recommendations in ACI 304R for measuring, mixing, transporting, and placing concrete.
- E. Do not add water to concrete during delivery, at Project site, or during placement.
- F. 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.
- G. Consolidate concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping. Use equipment and procedures to consolidate concrete according to recommendations in 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 reinforcement, dowels, and joint devices.
- H. 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 approved by Owner's Representative.
- I. Screed pavement surfaces with a straightedge and strike off. Commence initial floating using bull floats or darbies to form an open textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading dry-shake surface treatments.
- J. Curbs: When curb forming machine is used for curb placement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce curbs to required cross section, lines, grades, finish, and jointing as specified for formed concrete. If results are not approved, remove and replace with formed concrete.
- K. When adjoining pavement lanes are placed in separate pours, do not operate equipment on concrete until pavement has attained 85 percent of its 28-day compressive strength.

- L. Cold-Weather Placement: Comply with ACI 306.1 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, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F 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 specified and approved in mix designs.

- M. Hot-Weather Placement: Place concrete according to recommendations in ACI 305R and as follows when hot-weather conditions exist:
 - 1. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90 deg F. Chilled mixing water 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 reinforcement steel with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
 - 3. Fog-spray forms, reinforcement steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.6 CONCRETE FINISHING

- A. General: Wetting of concrete surfaces during screeding, initial floating, or finishing operations is prohibited.

- B. Float Finish: Begin the second floating operation 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. Cut down high spots, and fill low spots. Refloat surface immediately to uniform granular texture.
 - 1. Medium-textured Broom Finish: Draw a soft bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform texture.
 - 2. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch deep with a stiff-bristled broom, perpendicular to line of traffic.

3.7 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and follow recommendations in ACI 305R for hot-weather protection during curing.

- B. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

- 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 seven 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 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 written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified independent testing and inspection agency to sample materials, perform tests, and submit test reports during concrete placement according to requirements specified in this Article.
- B. Testing Agency: Owner will engage a qualified testing and inspection agency to sample materials, perform tests, and submit test reports during concrete placement. Sampling and testing for quality control may include those specified in this Article.
- C. Testing Services: Testing shall be performed according to the following requirements:
 - 1. Sampling Fresh Concrete: Representative samples of fresh concrete shall be obtained according to ASTM C 172, except modified for slump to comply with ASTM C 94.
 - 2. Slump: ASTM C 143; one test at point of placement for each compressive-strength test, but not less than one test for each day's pour of each type of concrete. Additional tests will be required when concrete consistency changes.
 - 3. Air Content: ASTM C 231, pressure method; one test for each compressive-strength test, but not less than one test for each day's pour of each type of air-entrained concrete.
 - 4. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each set of compressive-strength specimens.
 - 5. Compression Test Specimens: ASTM C 31/C 31M; one set of four standard cylinders for each compressive-strength test, unless otherwise indicated. Cylinders shall be molded and stored for laboratory-cured test specimens unless field-cured test specimens are required.
 - 6. Compressive-Strength Tests: ASTM C 39; one set for each day's pour of each concrete class exceeding 5 cu. yd., but less than 25 cu. yd., plus one set for each additional 50 cu. yd.. One specimen shall be tested at 7 days and two specimens at 28 days; one specimen shall be retained in reserve for later testing if required.

7. When frequency of testing will provide fewer than five compressive-strength tests for a given class of concrete, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
 8. When total quantity of a given class of concrete is less than 50 cu. yd., Owner's Representative may waive compressive-strength testing if adequate evidence of satisfactory strength is provided.
 9. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, current operations shall be evaluated and corrective procedures shall be provided for protecting and curing in-place concrete.
 10. Strength level of concrete will be considered satisfactory if averages of sets of three consecutive compressive-strength test results equal or exceed specified compressive strength and no individual compressive-strength test result falls below specified compressive strength by more than 500 psi.
- D. Test results shall be reported in writing to Owner's Representative, concrete manufacturer, and Contractor within 24 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing agency, concrete type and class, location of concrete batch in pavement, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
- E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Owner's Representative but will not be used as the sole basis for approval or rejection.
- F. Additional Tests: Testing agency shall make additional tests of the concrete when test results indicate slump, air entrainment, concrete strengths, or other requirements have not been met, as directed by Owner's Representative. Testing agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed.

3.9 REPAIRS AND PROTECTION

- A. Remove and replace concrete pavement that is broken, damaged, or defective, or does not meet requirements in this Section.
- B. Drill test cores where directed by Owner's Representative when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with portland cement concrete bonded to pavement with epoxy adhesive.
- C. Protect concrete from damage. Exclude traffic from new construction for at least 14 days after placement. When construction traffic is permitted, maintain pavement as clean as possible by removing surface stains and spillage of materials as they occur.
- D. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 32 13 13

SECTION 32 13 73 - PAVEMENT JOINTS

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. Expansion and contraction joints within cement concrete pavement.
 - 2. Joints between cement concrete and asphalt pavement.
- B. Related Sections include the following:
 - 1. Division 32 Section "Hot-Mix Asphalt Paving" for constructing joints between concrete and asphalt pavement.
 - 2. Division 32 Section "Portland Cement Concrete Pavement" for constructing joints in concrete pavement.

1.3 SUBMITTALS

- A. Product Data: For each joint material product indicated.
- B. Samples for Verification: For each type and color of joint sealant required.
- C. Product Certificates: For each type of joint sealant and accessory, signed by product manufacturer.
- D. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for sealants.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who has completed installations similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a minimum 5-year record of successful in-service performance.
- B. Source Limitations: Obtain each type of joint sealant for a specific application through one source from a single manufacturer.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Project site in original unopened containers or bundles with labels indicating manufacturer, product name and designation.
- B. Store and handle materials to comply with manufacturer's written instructions to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

1.6 PROJECT CONDITIONS

- A. Do not proceed with installation of joint materials under the following conditions:
 - 1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F.
 - 2. When joint substrates are wet or covered with frost.
 - 3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
 - 4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

- A. Compatibility: Provide joint materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer based on testing and field experience.

PART 3- EXECUTION

3.1 EXAMINATION

- A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions.

3.3 INSTALLATION OF JOINT MATERIALS

- A. General: Comply with joint material manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.

- B. Install materials of type indicated and at position required to produce cross-sectional shapes and depths of installed materials relative to joint widths that allow optimum movement capability.
 - 1. Do not leave gaps between ends of joint materials.
 - 2. Do not stretch, twist, puncture, or tear joint materials.
- C. Provide recessed joint configuration of recess depth and at locations indicated.

3.4 PROTECTION

- A. Protect joint materials during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes.

END OF SECTION 32 13 73

SECTION 32 18 16.13 - PLAYGROUND PROTECTIVE SURFACING

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. Unitary synthetic poured rubber seamless surface.
2. Organic loose-fill surface.

B. Related Sections:

1. Division 31 Section "Earthwork" for filling and grading and for drainage/separation geotextiles and subbase courses.
2. Division 33 Section "Subdrainage" for playground subdrainage system.

1.3 DEFINITIONS

- A. Critical Height: Standard measure of shock attenuation. According to CPSC No. 325, this means "the fall height below which a life-threatening head injury would not be expected to occur."
- B. SBR: Styrene-butadiene rubber.

1.4 PERFORMANCE REQUIREMENTS

- A. Impact Attenuation: According to ASTM F 1292.
- B. Accessibility of Surface Systems: According to ASTM F 1951.
- C. Minimum Characteristics for Organic Loose-Fill Surfaces: According to ASTM F 2075.

1.5 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For each playground surface system, include materials, plans, cross sections, drainage, installation, penetration details, and edge termination..
- C. Samples for Initial Selection: For each type of playground surface system indicated.

1. Include similar Samples of playground surface system and accessories involving color selection.
- D. Samples for Verification: For each type of playground surface system indicated.
1. Minimum 1-quart loose-fill surface sealed in a container.
 2. 6-inch long by full-size cross section of border edging.
 3. Minimum 12-by-12-inch Sample of geosynthetic fabric.
 4. Minimum 6-by-6-inch Sample of geosynthetic, molded-sheet drainage panel.
- E. Product Schedule: For playground surface systems. Use same playground designations as indicated on Drawings.
- F. 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:
1. Extent of surface systems and use zones for equipment.
 2. Critical heights for playground surfaces and fall heights for equipment.
- G. Qualification Data: For qualified Installer.
- H. Material Certificates: For each type of loose-fill playground surface system, from manufacturer.
- I. Material Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each loose-fill playground surface system.
- J. Field quality-control reports.
- K. Maintenance Data: For playground surface system to include in maintenance manuals.
- L. Product Certificates: For each type of unitary synthetic playground surface system, form manufacturer.
- M. Warranty: Sample of special warranty.
- 1.6 QUALITY ASSURANCE
- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
- B. Source Limitations: Obtain playground surface system materials from single manufacturer.
1. Provide secondary materials including adhesives, primers, geosynthetics, and repair materials of type and from source recommended by manufacturer of playground surface system materials.
- C. Standards and Guidelines: Comply with CPSC No. 325, "Handbook for Public Playground Safety"; ASTM F 1292; and ASTM F 1487.

1.7 PROJECT CONDITIONS

- A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit playground surface system installation to be performed according to manufacturers' written instructions and warranty requirements.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of playground surface system that fail in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
 - a. Reduction in impact attenuation.
 - b. Deterioration of surface and other materials beyond normal weathering.
 2. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 UNITARY SYNTHETIC DUAL-DENSITY SEAMLESS SURFACE

- A. Surface System: Poured-in-place, two layer system with wearing course over cushion course. Provide manufacturer's standard thickness for each layer as required for overall thickness indicated, tested for impact attenuation according to ASTM F 1292 and for accessibility according to ASTM F 1951.
- B. Basis-of-Design Product: Subject to compliance with requirements, PlayBound Poured-in-Place playground surfacing system as manufactured by Surface America, Inc. or an approved comparable product equal in all respects. Color to be selected by owner from full standard color range offered by manufacturer.
1. Wearing Course: Formulation of recycled EPDM rubber particles, with minimum of 20 percent and maximum of 26 percent of ethylene propylene-diene-saturated polymethylene main chain along with other organic and inorganic components.
 2. Cushion Course: Manufacturer's standard formulation of 100% recycled SBR particles and polyurethane, site mixed and applied.
 3. Binder: Weather-resistant, UV-stabilized, flexible, nonhardening, 100 percent solids polyurethane complying with requirements of authorities having jurisdiction for nontoxic and low VOC content.
 4. Lacquer Top Coat: Manufacturer's standard polyurethane-based formulation.
 5. Critical Height: 3 feet.
 6. Overall Thickness: Not less than as required for critical height indicated.
 7. Primer/Adhesive: Manufacturer's standard primer and weather-resistant, moisture-cured polyurethane adhesive suitable for unit, substrate, and location indicated.
 8. Wearing Course Color(s): As selected by Architect from manufacturer's full range.
- C. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by playground surface system manufacturer.

2.2 ORGANIC LOOSE-FILL SURFACE

- A. Engineered Wood Fibers: Random-sized wood fibers, in manufacturer's standard fiber size, approximately 10 times longer than wide; containing no bark, leaves, twigs, or foreign or toxic materials according to ASTM F 2075; graded according to manufacturer's standard specification for material consistency for playground surfaces and for accessibility according to ASTM F 1951.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Fibar Group LLC (The); Fibar System 300.
 - b. Zeager Bros., Inc.; Wood Carpet.
 2. Critical Height: As indicated.
 3. Uncompressed Material Depth: Not less than 12 inches.

2.3 GEOSYNTHETICS

- A. Drainage/Separation Geotextile: Nonwoven, needle-punched geotextile, manufactured for subsurface drainage applications and made from polyolefins or polyesters. Complying with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:
1. Weight: 4 oz./sq. yd. according to ASTM D 5261.
 2. Water Flow Rate: 100 gpm/sq. ft. according to ASTM D 4491.
- B. Molded-Sheet Drainage Panel: Prefabricated, composite drainage panels made with drainage core and filter fabric.
1. Drainage Core: Three-dimensional, nonbiodegradable, molded-plastic-sheet material designed to effectively drain water under maximum fill pressures.
 2. Fabric: Nonwoven, needle-punched geotextile, specifically manufactured as a filter geotextile and made from polyolefins or polyesters; complying with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:
 - a. Weight: 4 oz./sq. yd. according to ASTM D 5261.
 - b. Water Flow Rate: 100 gpm/sq. ft. according to ASTM D 4491.
 3. Minimum Flow Rate: 9 gpm/foot according to ASTM D 4491.
- C. Weed-Control Barrier: Composite fabric geotextile consisting of woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, weighing not less than 4.8 oz./sq. yd..

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for maximum moisture content, subgrade and substrate conditions, drainage, and other conditions affecting performance of the Work.
- B. Hard-Surface Substrates: Verify that substrates are satisfactory for unitary playground surface system installation and that substrate surfaces are dry, cured, and uniformly sloped to drain within recommended tolerances according to playground surface system manufacturer's written requirements for cross-section profile.
 - 1. Asphalt Substrates: Verify that substrates are dry, sufficiently cured to bond with adhesive, free from surface defects, and free of dust, dirt, loose particles, grease, oil, and other contaminants incompatible with playground surface system or that may interfere with adhesive bond.
 - 2. Concrete Substrates: Verify that substrates are dry, free from surface defects, and free of laitance, glaze, efflorescence, curing compounds, form-release agents, hardeners, dust, dirt, loose particles, grease, oil, and other contaminants incompatible with playground surface system or that may interfere with adhesive bond. Determine adhesion, dryness, and acidity characteristics by performing procedures recommended in writing by playground surface system manufacturer.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. General: Prepare substrates to receive surfacing products according to playground surface system manufacturer's written instructions. Verify that substrates are sound and without high spots, ridges, holes, and depressions.

3.3 INSTALLATION, GENERAL

- A. General: Comply with playground surface system manufacturer's written installation instructions. Install playground surface system over area and in thickness indicated.

3.4 GEOSYNTHETIC INSTALLATION

- A. General: Install geosynthetics according to playground surface system manufacturer's and geosynthetic manufacturer's written instructions.
 - 1. Geotextiles: Completely cover area indicated, overlapping sides and edges a minimum of 8 inches with manufacturer's standard treatment for seams.
 - a. Perimeter: Adhere edges on all sides to top of perimeter curb or footing.

3.5 INSTALLATION OF SEAMLESS PLAYGROUND SURFACE SYSTEMS

- A. Seamless Surface: Mix and apply components of playground surface system according to manufacturer's written instructions to produce a uniform, monolithic wearing surface and impact-attenuating system of total thickness indicated.
1. Substrate Primer: Apply over prepared substrate at manufacturer's standard spreading rate for type of substrate.
 2. Poured Cushion Course: Spread evenly over primed substrate to form a uniform layer applied at manufacturer's standard spreading rate in one continuous operation, with a minimum of cold joints.
 3. Intercoat Primer: Over cured cushion course, apply primer at manufacturer's standard spreading rate.
 4. Wearing Course: Spread over primed base course to form a uniform layer applied at manufacturer's standard spreading rate in one continuous operation and, except where color changes, with no cold joints. Finish surface to produce manufacturer's standard wearing-surface texture.
 5. Edge Treatment: Fully adhere edges to substrate with full coverage of substrate. Maintain fully cushioned thickness required to comply with safety performance requirements.

3.6 INSTALLATION OF LOOSE-FILL PLAYGROUND SURFACE SYSTEMS

- A. Loose-Fill Edgings: Place as indicated, and permanently secure in place and attach to each other according to edging manufacturer's written instructions.
- B. Loose Fill: Place playground surface system materials [including manufacturer's standard amount of excess material for compacting naturally with time] [including manufacturer's standard amount of excess material for compacting mechanically] to required depths after installation of playground equipment support posts and foundations.
- C. Stabilizing Mats: Coordinate installation of mats and mat anchoring system with placing and compacting of loose fill.
- D. Grading: Uniformly compact and grade loose fill according to manufacturer's written instructions to an even surface free from irregular surface changes as indicated.
- E. Finish Grading: Hand rake to a smooth finished surface and to required elevations.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Testing Services: Testing and inspecting of completed applications of playground surface system shall take place according to ASTM F 1292.
- C. Remove and replace applications of playground surface system where test results indicate that it does not comply with requirements.
- D. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with requirements.

3.8 PROTECTION

- A. Seamless Systems: Prevent traffic over system for not less than 48 hours after installation.

END OF SECTION 32 18 16.13

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 SECTION INCLUDES

- A. Vinyl-coated coated chain link fencing, gates, and accessories for use around the stormwater management facility, electrical gear, gas gear and site areas.

1.3 RELATED SECTIONS

- A. Division 32 Section "Portland Cement Concrete Pavement".

1.4 SUBMITTALS

- A. Changes in specification may not be made after the bid date.
- B. Shop drawings: Layout of fences and gates with dimensions, fabrication drawings, details, and finishes of components, accessories, and post foundations.
- C. Product data: Manufacturer's catalog cuts indicating material compliance and specified options.
- D. Samples of materials (e.g., fabric, wires, and accessories).
- E. Warranty: Sample of special warranty.

1.5 PROJECT CONDITIONS

- A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which Installer agrees to repair or replace components of chain-link fences and gates that fail in materials or workmanship within specified warranty period.

- 1. Failures include, but are not limited to, the following:

- a. Faulty operation of gate operators and controls.
 - b. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
2. Warranty Period: Five years from date of Substantial Completion.

PART 2- PRODUCTS

2.1 MANUFACTURER

- A. Products from qualified manufacturers having a minimum of five years experience manufacturing thermally fused chain link fencing will be acceptable by the architect as equal. If approved in writing, ten days prior to bidding, and if they meet the following specifications for design, size, gauge of metal parts and fabrication.
- B. Obtain chain link fences and gates, including accessories, fittings, fastenings, from a single source.
- C. Approved Manufacturer: Anchor Fence/Master Halco Inc., Irving, TX, Phone (800) 729-0580 or approved equal.

2.2 CHAIN LINK FENCE FABRIC

- A. Metal fabric: ASTM A 491, galvanized steel core wire, 11 gauge wire (850 lbf breakload strength), black vinyl coated.
- B. Size: Helically wound and woven to heights of 4 feet or as indicated on drawings. Mesh opening size: 2" for SWM Facilities.
 1. $\frac{3}{4}$ " mini-mesh fabric for top of all segmental block retaining walls.
- C. Selvage of fabric on all fences, gate panels, to be knuckled at top and knuckled at bottom.

2.3 STEEL FENCE FRAMING

- A. Steel pipe - Type I: ASTM F 1083, standard weight schedule 40; minimum yield strength of 25,000 psi (170 MPa); sizes as indicated. Hot-dipped galvanized with minimum average 1.8 oz/ft² (550 g/m²) of coated surface area
- B. End and corner posts: 3" OD (76 mm) 5.79 lbs/ft (8.6 kg/m)
- C. Gate posts: 4" OD (101.6 mm) 9.11 lb/ft (13.6 kg/m)
- D. Line (intermediate) posts: 2" OD (64 mm) 2.72 lb/ft (4.0 kg/m)
- E. Rails and braces: 1-5/8" OD (42.2mm) 2.27 lbs/ft (3.4 kg/m)
- F. Polymer coating over metallic coating.
 1. Color: Match chain-link fabric Black, complying with ASTM F 934

2.4 FENCE ACCESSORIES

- A. Chain link fence accessories: (ASTM F 626) Provide items required to complete fence system. Galvanize each ferrous metal item and apply polymer coating finish to match framing.
- B. Post caps: Formed steel, cast malleable iron, or aluminum alloy weathertight closure cap for tubular posts. For each line post provide tops to permit passage of top rail.
- C. Top rail and brace ends: Pressed steel per ASTM F626, for connection of rail and brace to terminal posts.
- D. Top rail sleeves: 7" (178 mm) expansion sleeve with spring, allowing for expansion and contraction of top rail.
- E. Wire ties and clips: 9 gauge [0.148" (3.76 mm)] galvanized steel wire for attachment of fabric to line posts. Double wrap 13 gauge [0.092" (2.324 mm)] for rails and braces. Hog ring ties of 12-1/2 gauge [0.0985" (2.502 mm)] for attachment of fabric to tension wire.
- F. Brace and tension (stretcher bar) bands: Pressed steel. At square post provide tension bar clips.
- G. Tension (stretcher) bars: One piece lengths equal to 2" (50 mm) less than full height of fabric with a minimum cross-section of 3/16" x 3/4" (4.76 mm x 19 mm) or equivalent fiberglass rod. Provide tension (stretcher) bars where chain link fabric meets terminal posts.
- H. Bottom Tension wire: Aluminum coated steel wire, 7 gauge, [0.177" (4.5 mm)] diameter core wire with tensile strength of 75,000 psi (517 MPa). in accordance with ASTM A 824.
- I. Nuts and bolts: galvanized

2.5 SETTING MATERIALS

- A. Concrete: Minimum 28 day compressive strength of 3,000 psi (20 MPa).

PART 3- EXECUTION

3.1 EXAMINATION

- A. Verify areas to receive fencing are completed to final grades and elevations.
- B. Ensure property lines and legal boundaries of work are clearly established.
- C. Verify locations of all fences with Owner's Representative before beginning installation.

3.2 CHAIN LINK FENCE FRAMING INSTALLATION

- A. Install chain link fence in accordance with ASTM F 969 and manufacturer's instructions.
- B. Locate terminal post at each fence termination and change in horizontal or vertical direction of 30° or more.

- C. Space line posts uniformly as indicated on the drawings (not to exceed 10 feet on center).
- D. Concrete set all posts. Drill holes in firm, undisturbed or compacted soil. Holes shall be the greater of 16" diameter or 4 times the diameter of the outside of the post, and depths approximately 3" 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" (900 mm) below surface when in firm, undisturbed soil. Place concrete around posts in a continuous pour. Trowel finish around post. Slope to direct water away from posts.
 - 1. Gate hardware: Set Keepers, stops, sleeves, and other accessories into concrete.
- E. Check each post for vertical and top alignment, and maintain in position during placement and finishing operations.
- F. Bracing: Install horizontal pipe brace at mid-height for fences 6' and over, on each side of terminal posts. Firmly attach with fittings. Install diagonal truss rods at these points. Install braces and adjust truss rod, ensuring posts remain plumb.
- G. Tension wire: Provide tension wire at bottom of fabric. Install tension wire before stretching fabric and attach to each post with ties or clips. Secure tension wire to fabric with 12-1/2 gauge [.0985" (2.502 mm)] hog rings 24" on center (609.6 mm).
- H. Top rail: Install lengths, 21'. Connect joints with sleeves for rigid connections during expansion/contraction.

3.3 CHAIN LINK FABRIC INSTALLATION

- A. Fabric: Install fabric on outside of enclosures, and attach so that fabric remains in tension after pulling force is released. Embed bottom selvage 3" into finish grades. Attach fabric with wire ties to line posts at 15" on center and to rails, braces, and tension wire at 24" on center.
- B. Tension (stretcher) bars: Pull fabric taut; thread tension bar through fabric and attach to terminal posts with bands or clips spaced maximum of 15" on center.

3.4 GATE INSTALLATION

- A. Install gates plumb, level, and secure for full opening without interference.
- B. Attach hardware by means which will prevent unauthorized removal.
- C. Adjust hardware for smooth operation.

3.5 ACCESSORIES

- A. Tie wires: Bend ends of wire to minimize hazard to persons and clothing.
- B. Fasteners: Install nuts on side of fence opposite fabric side for added security.

3.6 CLEANING

- A. Clean up debris and unused material, and remove from the site.

END OF SECTION 32 31 13

SECTION 323119 – ORNAMENTAL PICKET FENCES

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. Ornamental picket fencing and accessories

1.3 SUBMITTALS

- A. Shop Drawings: Layout of fence and gates with dimensions, details and finishes of component accessories and post foundations.
- B. Product Data: Manufacturer's catalogue cuts indicating material compliance and specified options.
- C. Samples: Samples of materials, (e.g. finials, caps, and accessories).

PART 2 - PRODUCTS

2.1 MANUFACTURER

- A. Monumental Iron Works (Master-Halco), Irving, TX. (phone 800-729-0580). Products from other 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.
- B. Ornamental Picket Fence:
 - 1. Style: Imperial – Style B
 - a. Heights: 48" or as shown on plans

2.2 ORNAMENTAL PICKET FENCE

- A. Pickets: Galvanized square steel tubular members manufactured per ASTM A-924/A-924M, having a 45,000 psi (310 MPa) yield strength and hot-dip galvanized per ASTM A653/A653M

with a G90 zinc coating, 0.90 oz./sq. ft. Picket Size 3/4. Pickets are spaced 3-15/16" maximum face to face. Pickets are attached to rails at the factory using industrial drive rivets.

- B. Rails: "U" channels formed from hot-rolled structural steel having no pockets or shelves to hold water or moisture, 1-3/8" wide x 1-1/2" deep, 11 gauge (0.120") wall thickness. Punch rails to receive pickets and rivets and attach rails to rail brackets with 2 each, 1/4" industrial drive rivets. Size #4. Steel for rail produced per ASTM A-653/A-653M.
- C. Posts: Square tubular members, ASTM A500, hot-rolled structural quality steel, 45,000 psi yield strength, with ASTM A-653/A-653M hot-dipped galvanized G90 zinc coating. Minimum post size 2 1/2" (57.15 mm), having 14 gauge wall thickness.
- D. Accessories: Assembled panels with ornamental accessories attached using industrial drive rivets to prevent removal and vandalism.
- E. Finish: After all steel components have been galvanized, clean and prepare the surface of all components to assure complete adhesion of finish coat. Apply 2.5 mil (0.0635 mm) thickness of polyester resin based powder coating by electrostatic spray process. Bake finish for 20 minutes at 450° F metal temperature. Color: Black.
- F. Gate Frames: Fabricate ornamental picket swing gate using galvanized steel members, ASTM A78, structural quality steel, 45,000 psi tensile strength, with galvanized G90 coating. Frame members welded using stainless steel welded to form rigid one-piece unit. Minimum size vertical uprights, 2" square 13 gauge wall thickness.
- G. Bracing: Provide diagonal adjustable length truss rods on gates to prevent sag.
- H. Hardware Materials: Galvanized steel or malleable iron shapes to suit gate size.
- I. Hinges: Structurally capable of supporting gate leaf and allow opening and closing without binding. Non-lift_off type hinge design shall allow gate to swing 180 degrees.
- J. Latches: Capable of retaining gate in closed position and have provision for padlock.
- K. Gate Posts: Square members, ASTM A787, structural quality steel, 45,000 psi tensile strength, with galvanized G90 coating, 3" square.

2.3 ACCESSORIES

- A. Rail Attachment Brackets - die cast of zinc (ZAMAK #3 Alloy) per ASTM B86-83Z 33521. Ball and socket design capable of 30° swivel (up/down - left/right). Bracket to fully encapsulate rail end for complete security that is aesthetically pleasing.
- B. Industrial Drive Rivets: Of sufficient length to attach items in a secure non-rattling position. Rivet to have a minimum of 1100 lbs. (4894 N) holding power and a shear strength of 1500 lbs. (6674 N).
- C. Ornamental Picket Fence Accessories: Provide indicated items required to complete fence system. Galvanize each ferrous metal item in accordance with ASTM B695 and finish to match framing.

- D. Post Caps: Formed steel, cast of malleable iron or aluminum alloy, weathertight closure cap. Provide one Flat style post cap for each post.
- E. Rings: Cast aluminum. Attach ring to top rail by inserting mounting blocks into top rail and riveting through side of rail using 1/4" industrial drive rivet. Hold bottom of ring in place by dowel that protrudes from ring through predrilled hole in bottom rail.
- F. Picket Tops :
 - 1. Flat style picket top.

2.4 SETTING MATERIAL

- A. Concrete: Minimum 28 day compressive strength of 3000 psi.
- B. Installation in concrete curb: Nonshrink, nonmetallic grout.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify areas to receive fencing are completed to final grades and elevations.
- B. Ensure property lines and legal boundaries of work are clearly established.

3.2 INSTALLATION

- A. Install fence in accordance with manufacturer's instructions.
- B. Space posts uniformly at 7'8-3/4" maximum face to face 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" 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" 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. Mounting in concrete curbs and walls: Take field measurements of inplace concrete curb to verify spacing. Core drill holes of adequate size to allow post installation with nonshrink grout.
- E. Check each post for vertical and top alignment, and maintain in position during placement and finishing operation.
- F. Align fence panels between posts. Firmly attach rail brackets to posts with 1/4" bolt and lock nut, ensuring panels and posts remain plumb.

3.3 ACCESSORIES

- A. Install post caps and other accessories to complete fence.

3.4 CLEANING

- A. Clean up debris and unused material, and remove from site.

END OF SECTION 32311

SECTION 32 92 00 - LAWNS AND GRASSES

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. Seeding.
- 2. Sodding.

- B. Related Sections:

- 1. Division 31 Section "Site Clearing" for topsoil stripping and stockpiling.
- 2. Division 31 Section "Earthwork" for excavation, filling and backfilling, and rough grading.
- 3. Division 32 Section "Landscaping" for border edgings.

1.3 DEFINITIONS

- A. Finish Grade: Elevation of finished surface of planting soil.
- B. Manufactured Soil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- C. Planting Soil: Native or imported topsoil, manufactured topsoil, or surface soil modified to become topsoil; mixed with soil amendments.
- D. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill immediately beneath planting soil.
- E. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or 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.

1. Certification of each seed mixture for turfgrass sod, identifying source, including name and telephone number of supplier.
- C. Qualification Data: For qualified landscape Installer.
- D. Product Certificates: For soil amendments and fertilizers, from manufacturer.
- E. Material Test Reports: For existing surface soil and imported topsoil.
- F. Planting Schedule: Indicating anticipated planting dates for each type of planting.
- G. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of lawns during a calendar year. Submit before expiration of required initial maintenance periods.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful lawn establishment.
 1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when planting is in progress.
 2. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.
- B. Soil-Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
- C. Topsoil Analysis: Furnish soil analysis by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of topsoil.
 1. Report suitability of topsoil for lawn growth. State-recommended quantities of nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory topsoil.
- D. Preinstallation Conference: Conduct conference at Project site.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Seed: Deliver seed in original sealed, labeled, and undamaged containers.
- B. Sod: Harvest, deliver, store, and handle sod according to requirements in TPI's "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in its "Guideline Specifications to Turfgrass Sodding." Deliver sod in time for planting within 24 hours of harvesting. Protect sod from breakage and drying.

1.7 PROJECT CONDITIONS

- A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of Substantial Completion.
 - 1. Spring Planting: March 1 through May 15.
 - 2. Fall Planting: August 15 through October 15.
- B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit.

1.8 MAINTENANCE SERVICE

- A. Initial Lawn Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable lawn is established, but for not less than the following periods:
 - 1. Seeded Lawns: 60 days from date of Substantial Completion.
 - a. When initial maintenance period has not elapsed before end of planting season, or if lawn is not fully established, continue maintenance during next planting season.
 - 2. Sodded Lawns: 60 days from date of Substantial Completion.

PART 2- PRODUCTS

2.1 SEED

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.
- B. Grass Seed Mix: Blend of three varieties of Improved Tall Fescue as recommended by the Maryland Extension Service. Seed shall be Maryland Certified with seed certification tags provided to and approved by the Architect prior to installation.

2.2 TURFGRASS SOD

- A. Turfgrass Sod: Certified, complying with TPI's "Specifications for Turfgrass Sod Materials" in its "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture, strongly rooted, and capable of vigorous growth and development when planted.
- B. Turfgrass Species: Sod of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:
 - 1. Sun and Partial Shade: blend of three varieties of Improved Tall Fescue as recommended by the Maryland Extension Service from Maryland Certified seed.

2.3 TOPSOIL

- A. Topsoil: ASTM D 5268, pH range of 5.5 to 7, a minimum of 6 percent organic material content; free of stones 1 inch or larger in any dimension and other extraneous materials harmful to plant growth.
 - 1. Topsoil Source: Reuse surface soil stockpiled on-site. Verify suitability of stockpiled surface soil to produce topsoil. Clean surface soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.
 - a. Supplement with imported or manufactured topsoil from off-site sources when quantities are insufficient. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches deep; do not obtain from bogs or marshes.
 - 2. Topsoil Source: Import topsoil or manufactured topsoil from off-site sources. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches deep; do not obtain from bogs or marshes.
 - 3. Topsoil Source: Amend existing in-place surface soil to produce topsoil. Verify suitability of surface soil to produce topsoil. Clean surface soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.
 - a. Surface soil may be supplemented with imported or manufactured topsoil from off-site sources. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches deep; do not obtain from bogs or marshes.

2.4 INORGANIC SOIL AMENDMENTS

- A. Lime: ASTM C 602, agricultural limestone containing a minimum of 80 percent calcium carbonate equivalent and as follows:
 - 1. Class: T, with a minimum of 99 percent passing through No. 8 sieve and a minimum of 75 percent passing through No. 60 sieve.
 - 2. Class: O, with a minimum of 95 percent passing through No. 8 sieve and a minimum of 55 percent passing through No. 60 sieve.
 - 3. Provide lime in form of dolomitic limestone.
- B. Sulfur: Granular, biodegradable, containing a minimum of 90 percent sulfur, with a minimum of 99 percent passing through No. 6 sieve and a maximum of 10 percent passing through No. 40 sieve.
- C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
- D. Aluminum Sulfate: Commercial grade, unadulterated.
- E. Perlite: Horticultural perlite, soil amendment grade.
- F. Agricultural Gypsum: Finely ground, containing a minimum of 90 percent calcium sulfate.
- G. Sand: Clean, washed, natural or manufactured, free of toxic materials.

- H. Diatomaceous Earth: Calcined, diatomaceous earth, 90 percent silica, with approximately 140 percent water absorption capacity by weight.
- I. Zeolites: Mineral clinoptilolite with at least 60 percent water absorption by weight.

2.5 ORGANIC SOIL AMENDMENTS

- A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 3/4-inch sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
 - 1. Organic Matter Content: 50 to 60 percent of dry weight.
 - 2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
- B. Peat: Sphagnum peat moss, partially decomposed, finely divided or granular texture, with a pH range of 3.4 to 4.8.
- C. Peat: Finely divided or granular texture, with a pH range of 6 to 7.5, containing partially decomposed moss peat, native peat, or reed-sedge peat and having a water-absorbing capacity of 1100 to 2000 percent.
- D. Wood Derivatives: Decomposed, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture, free of chips, stones, sticks, soil, or toxic materials.
 - 1. In lieu of decomposed wood derivatives, mix partially decomposed wood derivatives with ammonium nitrate at a minimum rate of 0.15 lb/cu. ft. of loose sawdust or ground bark, or with ammonium sulfate at a minimum rate of 0.25 lb/cu. ft. of loose sawdust or ground bark.
- E. Manure: Well-rotted, unleached, 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.

2.6 PLANTING ACCESSORIES

- A. Selective Herbicides: EPA registered and approved, of type recommended by manufacturer for application.

2.7 FERTILIZER

- A. 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 formaldehyde, phosphorous, and potassium in the following composition:
 - 1. Composition: 1 lb/1000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
 - 2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

- B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
 - 1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
 - 2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

2.8 MULCHES

- A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.
- B. Peat Mulch: Sphagnum peat moss, partially decomposed, finely divided or granular texture, with a pH range of 3.4 to 4.8.
- C. Peat Mulch: Finely divided or granular texture, with a pH range of 6 to 7.5, containing partially decomposed moss peat, native peat, or reed-sedge peat and having a water-absorbing capacity of 1100 to 2000 percent.
- D. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch sieve; soluble salt content of 2 to 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
 - 1. Organic Matter Content: 50 to 60 percent of dry weight.
 - 2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
- E. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic; free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.
- F. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.
- G. Asphalt Emulsion: ASTM D 977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive lawns and grass for compliance with requirements and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
 - 1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
 - 2. Protect grade stakes set by others until directed to remove them.
- B. 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.

3.3 LAWN PREPARATION

- A. Limit lawn subgrade preparation to areas to be planted.
- B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 6 inches. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 - 1. Apply fertilizer directly to subgrade before loosening.
 - 2. Thoroughly blend planting soil mix off-site before spreading or spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil mix.
 - a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
 - b. Mix lime with dry soil before mixing fertilizer.
 - 3. Spread topsoil to a depth of 4 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
- C. Unchanged Subgrades: If lawns are to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
 - 1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
 - 2. Loosen surface soil to a depth of at least 6 inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 6 inches of soil. Till soil to a homogeneous mixture of fine texture.
 - a. Apply fertilizer directly to surface soil before loosening.
 - 3. Remove stones larger than 1 inch in any dimension and sticks, roots, trash, and other extraneous matter.
 - 4. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.
- D. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.
- E. Moisten prepared lawn areas before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

- F. Before planting, restore areas if eroded or otherwise disturbed after finish grading.

3.4 SEEDING

- A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
 - 1. Do not use wet seed or seed that is moldy or otherwise damaged.
 - 2. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.
- B. Sow seed at a total rate of 5 to 8 lb/1000 sq. ft.
- C. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.
- D. Protect seeded areas with slopes exceeding installed and stapled according to manufacturer's written instructions.
- E. Protect seeded areas with erosion-control mats where shown, installed and anchored according to manufacturer's written instructions.
- F. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre to form a continuous blanket 1-1/2 inches in loose depth over seeded areas. Spread by hand, blower, or other suitable equipment.
 - 1. Anchor straw mulch by crimping into soil with suitable mechanical equipment.
 - 2. Bond straw mulch by spraying with asphalt emulsion at a rate of 10 to 13 gal./1000 sq. ft. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.
- G. Protect seeded areas from hot, dry weather or drying winds by applying mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a depth of 3/16 inch, and roll surface smooth.

3.5 HYDROSEEDING

- A. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
 - 1. Mix slurry with fiber-mulch manufacturer's recommended tackifier.
 - 2. Apply slurry uniformly to all areas to be seeded in a one-step process. Apply slurry at a rate so that mulch component is deposited at not less than 1500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate.

3.6 SODDING

- A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

- B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to subgrade or sod during installation. Tamp and roll lightly to ensure contact with subgrade, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
 - 1. Lay sod across angle of slopes exceeding 1:3.
 - 2. Anchor sod on slopes exceeding 1:6 with wood pegs spaced as recommended by sod manufacturer but not less than 2 anchors per sod strip to prevent slippage.
- C. Saturate sod with fine water spray within two hours of planting. During first two weeks after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

3.7 LAWN MAINTENANCE

- A. Maintain and establish lawn by watering, fertilizing, weeding, mowing, trimming, replanting, and other operations. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth lawn. Provide materials and installation the same as those used in the original installation.
 - 1. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
- B. Watering: Provide and maintain temporary piping, hoses, and lawn-watering equipment to convey water from sources and to keep lawn uniformly moist to a depth of 4 inches.
 - 1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
 - 2. Water lawn with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.
- C. Mow lawn as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:
 - 1. Mow grass to a height of 1/2 inch or less.
 - 2. Mow grass to a height of 1/2 to 1 inch.
 - 3. Mow grass to a height of 1 to 2 inches.
 - 4. Mow grass to a height of 1-1/2 to 2 inches.
 - 5. Mow grass to a height of 2 to 3 inches.

3.8 SATISFACTORY LAWNS

- A. Lawn installations shall meet the following criteria as determined by Architect:

1. Satisfactory Seeded Lawn: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 5 by 5 inches.
 2. Satisfactory Sodded Lawn: At end of maintenance period, a healthy, well-rooted, even-colored, viable lawn has been established, free of weeds, open joints, bare areas, and surface irregularities.
- B. Use specified materials to reestablish lawns that do not comply with requirements and continue maintenance until lawns are satisfactory.

3.9 CLEANUP AND PROTECTION

- A. Promptly remove soil and debris, created by lawn work, from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
- B. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after lawn is established.
- C. Remove nondegradable erosion-control measures after grass establishment period.

END OF SECTION 32 92 00

SECTION 32 93 00 - LANDSCAPING

PART 1- GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions, Supplemental Specifications and Special Provisions, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:

1. Trees.
2. Shrubs.
3. Ground covers.
4. Plants.
5. Lawns.
6. Topsoil and soil amendments for trees, shrubs and groundcovers.
7. Fertilizers and mulches.
8. Stakes and guys.

1.3 RELATED WORK IN OTHER SECTIONS:

- A. Division 32 Section "Lawns and Grasses" for furnishing, placing and preparing topsoil for lawns, and finish grading.

1.4 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and as noted herein.

- 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 plants, trees, shrubs, and planting materials comply with specified requirements.
3. Landscape installer/subcontractor's written certification to the owner listing the botanical name, size, quantity of all plant material installed, and containing the following certification signed and dated by the subcontractor (owner or president): "I, (owner or president's name), certify to Baltimore County Public Schools, that the above listed plant materials types, sizes and quantities were installed at Baltimore County Public Schools, in accordance with all the requirements of the drawings and specifications. "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.

- C. 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 imported topsoil.
 - 2. Shredded Hardwood Mulch
- D. Planting schedule indicating anticipated dates and locations for each type of planting.

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.
- B. Testing Agency Qualifications: To qualify for acceptance, an independent testing agency must demonstrate to Owner's Representative'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. Provide quality, size, genus, species, and variety of trees and shrubs indicated, complying with applicable requirements of ANSI Z60.1 "American Standard for Nursery Stock."
- D. 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 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 satisfactory topsoil.
- E. Measurements: Measure trees and shrubs according to ANSI Z60.1 with branches and trunks or canes in their normal position. Do not prune to obtain required sizes. Take caliper measurements 6 inches (150 mm) above ground for trees up to 4 inch (100 mm) caliper size, and 12 inches (300 mm) above ground for larger sizes. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip-to-tip.
- F. Preinstallation Conference: Conduct conference at Project site to comply with requirements of Division 01 Section "Project Meetings."
- G. Prior Approvals: Plant material shall be tagged at the source by the Owner's Representative unless the requirement is specifically waived; locations of all plant materials and bed lines shall be staked or flagged before landscaping begins and the locations are subject to approval or field adjustment by the Owner's Representative.
- H. Post-installation Written Acceptance: All plant material and landscaping must be approved by the Owner's Representative after complete installation. Written Acceptance is a letter from the Owner's Representative to the Contractor stating that all plant material and landscaping has been installed as required by the contract documents. Post installation Written Acceptance

issued by the owner does not constitute a waiver regarding required quantities or reimbursement of consultant fees required to verify quantities.

- I. Cost to verify quantities of ground cover and perennials: Notwithstanding any other provision contained herein, Contractor acknowledges that Owner and Owner's representatives are reasonably relying upon Contractor to install the correct quantities of ground cover, perennials, and annuals defined for this purposes of this paragraph as plant material spaced less than 30" on center, in accordance with the Plant Schedules shown on the drawings. If after giving the Contractor a written request to check quantities, Owner or Owner's representative remains uncertain that the quantities installed meet or exceed those required by the drawings, Owner shall give written notice to the Contractor of the date and time that Owner's representative will field verify quantities. In the event that quantities do not meet or exceed the quantities required by the drawings, the Contractor shall install additional plants to achieve the required quantities. IF THE DEFICIENCY IN QUANTITIES FOR ANY GROUPING(S) OF PLANTS EXCEEDS 2%, THE CONTRACTOR SHALL REIMBURSE OWNER, IN THE FORM OF A CREDIT TO BE DEDUCTED FROM PAYMENTS OTHERWISE DUE UNDER THE CONTRACT, FOR THE CONSULTANT'S FEES FOR VERIFYING THE DEFICIENT PLANT QUANTITIES.

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. Trees and Shrubs: Deliver freshly dug trees and shrubs. Do not prune before delivery, except as approved by a representative of Baltimore County Public Schools. Protect bark, branches, and root systems from sun scald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy natural shape. Provide protective covering during delivery. Do not drop trees and shrubs during delivery.
- C. Handle balled and burlapped stock by the root ball, not trunk or branches.
- D. Deliver trees, shrubs, ground covers, and plants after preparations for planting have been completed and install immediately. If planting is delayed more than 6 hours after delivery, set planting materials in shade, protect from weather and mechanical damage, and keep roots moist at all times.
 - 1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
 - 2. Do not remove container-grown stock from containers before time of planting.
 - 3. Water root systems of trees and shrubs stored on site with a fine-mist spray. Water as often as necessary to maintain root systems in a moist condition.
- E. Topsoil: Store topsoil in an area protected by sediment control measures; do not store topsoil in an area that would prevent drainage, cause flooding, or result in erosion of the topsoil. Take all measures necessary to prevent the stored topsoil from being exposed to excessive moisture that would make the topsoil unworkable.

1.7 PROJECT CONDITIONS

- A. Subgrade: Verify that elevation of subgrade is correct so that with the addition of the required depths of planting mix finished grades are achieved.
- B. 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.
- C. Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify site consultant before planting.

1.8 COORDINATION AND SCHEDULING

- A. Coordinate installation of planting materials during normal planting seasons for each type of plant material required.
- B. Schedule a site meeting for the Owner's Representative to approve stakeout of plant material and bed line.
- C. After planting, schedule a site meeting for a representative of Baltimore County Public Schools to inspect all planting. Request a written punch list and a Written Acceptance of the plant material that has been installed.
- D. Within 30 days of receiving Written Acceptance of the plant material from a representative of Baltimore County Public Schools, deliver to a representative of Baltimore County Public Schools a written maintenance schedule which includes dates, planned maintenance activities, and which confirms the dates when the special warranty period and maintenance period end.

1.9 WARRANTY

- A. General Warranty: The special 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. Special Warranty: Warrant the following planting materials for one full growing season (March 1 through October 31), but not less than one year, after the date of Written Acceptance, against defects including death and unsatisfactory growth, except for defects resulting from abuse by Owner, abnormal weather conditions unusual for warranty period (except that drought does not void the warranty because the contractor is obligated to water under Section 1.9), or incidents that are beyond Contractor's control.
 - 1. Trees.
 - 2. Shrubs.
 - 3. Ground covers.
- C. Remove and replace dead planting materials immediately unless required to plant in the succeeding planting season. Replacement plant material shall be under the same warranty.

- D. Replace planting materials that are more than 25 percent dead or in an unhealthy condition at end of warranty period.

1.10 TREE AND SHRUB MAINTENANCE

- A. Maintain trees and shrubs by pruning, cultivating, watering, weeding, fertilizing, restoring planting saucers, tightening and repairing stakes and guy supports, and resetting to proper grades or vertical position, as required to establish healthy, viable plantings. Spray as required to keep trees and shrubs free of insects and disease. Restore or replace damaged tree wrappings. Maintain trees, shrubs and ground cover for the following period:

- 1. Maintenance Period: **24** months following the date of Written Acceptance.

PART 2 - PRODUCTS

2.1 TREE AND SHRUB MATERIAL

- A. General: Furnish nursery-grown trees and shrubs conforming to ANSI Z60.1, with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully-branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
- B. Label each tree and shrub with securely attached, waterproof tag bearing legible designation of botanical and common name.

2.2 SHADE AND FLOWERING TREES

- A. Shade Trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, of height and caliper indicated, conforming to ANSI Z60.1 for type of trees required.
- B. Small Trees: Small upright or spreading type, branched or pruned naturally according to species and type, and with relationship of caliper, height, and branching recommended by ANSI Z60.1, and stem form as follows:
 - 1. Form: Single stem (unless otherwise noted on the drawings).
- C. Provide balled and burlapped trees.
- D. Container-grown trees will be acceptable in lieu of balled and burlapped trees subject to meeting ANSI Z60.1 limitations for container stock.

2.3 DECIDUOUS SHRUBS

- A. Form and Size: Deciduous shrubs with not less than the minimum number of canes required by and measured according to ANSI Z60.1 for type, shape, and height of shrub.
- B. Provide balled and burlapped deciduous shrubs.

- C. Container-grown deciduous shrubs will be acceptable in lieu of balled and burlapped deciduous shrubs subject to meeting ANSI Z60.1 limitations for container stock.

2.4 CONIFEROUS EVERGREENS

- A. Form and Size: Normal-quality, well-balanced, coniferous evergreens, of type, height, spread, and shape required, conforming to ANSI Z60.1.
- B. Form and Size: Specimen-quality, exceptionally heavy, tightly knit, symmetrically shaped Grade X coniferous evergreens.
- C. Provide balled and burlapped coniferous evergreens.
 - 1. Container-grown coniferous evergreens will be acceptable in lieu of balled and burlapped coniferous evergreens subject to meeting ANSI Z60.1 limitations for container stock.

2.5 BROADLEAF EVERGREENS

- A. Form and Size: Normal-quality, well-balanced, broadleaf evergreens, of type, height, spread, and shape required, conforming to ANSI Z60.1.
- B. Provide balled and burlapped broadleaf evergreens.
 - 1. Container-grown broadleaf evergreens will be acceptable in lieu of balled and burlapped broadleaf evergreens subject to meeting ANSI Z60.1 limitations for container stock.

2.6 GROUND COVERS AND PLANTS

- A. Provide ground covers and plants established and well rooted in removable containers or integral peat pots and with not less than the minimum number and length of runners required by ANSI Z60.1 for the pot size indicated.

2.7 TOPSOIL FOR LANDSCAPE PLANTING MIX

- A. Topsoil may be obtained from on-site stock piles or provided by the Contractor. Topsoil shall have a sandy-loam composition, and shall not contain any subsoil. Topsoil shall be free from plants, plant parts, Bermuda Grass, Quack Grass, Johnsongrass, Nutsedge, poison ivy, Canada thistle, and other plant material. It shall not contain slag, cinders, lumps, sticks, roots, woodchips, sawdust, trash, glass, rock, gravel, or any other extraneous material. It shall meet or exceed the requirements of ASTM D 5268, have a pH range of 6.0 to 7.5, have a minimum 4 percent organic content by weight, have soluble salts less than 500 parts per million, be free of stones 1/2 inch or larger in any dimension and other deleterious materials harmful to plant growth. The on-site topsoil may be adjusted with soil amendments to meet these requirements.

2.8 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.
- B. Aluminum Sulfate: Commercial grade, unadulterated.
- C. Organic Compost Leafgo (obtained from Maryland Environmental Services) or other approved organic compost shall be a screened (3/8" maximum particle size), high organic compost, non-toxic to plants. The minimum organic content shall be 60%; pH range of 7.3 to 8.2; maximum soluble salts 12 mmhos/cm.
- D. Sand: Clean, washed, natural or manufactured sand, free of toxic materials.
- E. Manure: Well-rotted, unleached 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.
- F. Water: Potable
- G. High organic compost. Minimum 40% organic matter, pH range of 6.0 to 8.2, maximum soluble salts 12 mmhos/cm, CEC range 55 to 125 meq/100g.

2.9 FERTILIZER

- A. Bonemeal: Commercial, raw, finely ground; minimum of 4 percent nitrogen and 20 percent phosphoric acid.
- B. 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.

2.10 MULCHES

- A. Organic Mulch: Organic mulch, free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:
 - 1. Type: Shredded hardwood.

2.11 STAKES AND GUYS

- A. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, redwood, or pressure-preservative-treated softwood, free of knots, holes, cross grain, and other defects, 2 by 2 inches (50 by 50 mm) by length indicated, pointed at one end.
- B. Guy and Tie Wire: ASTM A 641 (ASTM A 641M), Class 1, galvanized-steel wire, 2-strand, twisted, 0.106 inch (2.7 mm) in diameter.

- C. Guy Cable: 5-strand, 3/16 inch (4.8 mm) diameter, galvanized-steel cable, with zinc-coated turn buckles, 3 inch (75 mm) long minimum, with two 3/8 inch (10 mm) galvanized eyebolts.
- D. Hose Chafing Guard: Reinforced rubber or plastic hose at least 1/2 inch (13 mm) in diameter, black, cut to lengths required to protect tree trunks from damage.
- E. Flags: Standard surveyor's plastic flagging tape, white, 6 inches (150 mm) long.

PART 3- EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive landscaping for compliance with requirements for conditions affecting performance of work of this Section. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Substitutions of plant material shall not be allowed without prior written approval by the Owner's Representative. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, and obtain written acceptance from a representative of Baltimore County Public Schools before the start of planting work. Make adjustments as required by a representative from Baltimore County Public Schools.

3.3 PLANTING SOIL PREPARATION

- A. Before mixing, clean topsoil of roots, plants, sods, stones, clay lumps, and other extraneous materials harmful to plant growth.
- B. Mix soil amendments and fertilizers with topsoil at rates indicated. Delay mixing fertilizer if planting does not follow placing of planting soil within a few days.
- C. For tree pit or trench backfill, mix planting soil before backfilling and stockpile at site.
- D. For planting beds, mix planting soil either prior to planting or apply on surface of topsoil and mix thoroughly before planting.

3.4 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 4 inches (100 mm). Remove stones and clay lumps larger than 1-1/2 inches (38 mm) in any dimension and all sticks, roots, sod, vegetation, rubbish, and other extraneous materials, and legally dispose of it off the Owner's property.
- C. Spread topsoil to a minimum depth of 4 inches, preferably 6" or more.

- D. Apply soil amendments and initial fertilizers as required by the soil analysis report, and mix thoroughly into top 4 inches (100 mm) of soil. Till soil to a homogenous mixture of fine texture.
- 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. Rake to remove stones and clay lumps larger than 3/4 inches in any dimension, and all sticks, roots, sod, vegetation, rubbish, and other extraneous materials, and legally dispose of it off the Owner's property.
- 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.

3.5 GROUND COVER AND PLANT BED PREPARATION

- A. Loosen subgrade of planting bed areas to a minimum depth of 6 inches (150 mm). Remove stones larger than 1-1/2 inches (38 mm) in any dimension and sticks, roots, rubbish, and other extraneous materials.
- B. Spread planting soil mixture to depth required to meet thickness, grades, and elevations shown, after light rolling and natural settlement. Place approximately 1/2 the thickness of planting soil mixture required. Work into top of loosened subgrade to create a transition layer and then place remainder of planting soil mixture.
- C. Till soil in beds to a minimum depth of 8 inches (200 mm) and mix with specified soil amendments and fertilizers.
- D. Remove soil to a minimum depth of 8 inches (200 mm) and replace with prepared planting soil mixture.

3.6 EXCAVATION FOR TREES AND SHRUBS

- A. Pits and Trenches: Excavate with vertical sides and with bottom of excavation slightly raised at center to assist drainage. Loosen hard subsoil in bottom of excavation.
 - 1. Balled and Burlapped Trees and Shrubs: Excavate approximately 1-1/2 times as wide as ball diameter and equal to ball depth, plus the following setting layer depth:
 - a. Setting Layer: Allow 9 inches (225 mm) of planting soil.
 - 2. Container-Grown Trees and Shrubs: Excavate to container width and depth, plus the following setting-layer depth:
 - a. Setting Layer: Allow 6 inches (150 mm) of planting soil.
 - 3. Where drain tile is shown or required under planted areas, excavate to top of porous backfill over tile.
- B. Obstructions: Notify a representative of Baltimore County Public Schools if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

1. Hardpan Layer: Drill 6 inch (150 mm) diameter holes into free-draining strata or to a depth of 10 feet (3 m), whichever is less, and backfill with free-draining material.
- C. Drainage: Notify Owner's Representative if subsoil conditions evidence unexpected water seepage or retention in tree or shrub pits.
- D. Fill excavations with water and allow to percolate out, before placing setting layer and positioning trees and shrubs.

3.7 PLANTING TREES AND SHRUBS

- A. Set balled and burlapped stock plumb and in center of pit or trench with top of ball raised above adjacent finish grades as indicated.
 1. Place stock on setting layer of compacted planting soil.
 2. Remove burlap and wire baskets from tops of balls and partially from sides, but do not remove from under balls. Remove pallets, if any, before setting. Do not use planting stock if ball is cracked or broken before or during planting operation.
 3. Place backfill around ball in layers, tamping to settle backfill and eliminate voids and air pockets. When pit is approximately 1/2 backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more is absorbed. Water again after placing and tamping final layer of backfill.
- B. Set container-grown stock plumb and in center of pit or trench with top of ball raised above adjacent finish grades as indicated.
 1. Carefully remove containers so as not to damage root balls
 2. Place stock on setting layer of compacted planting soil.
 3. Place backfill around ball in layers, tamping to settle backfill and eliminate voids and air pockets. When pit is approximately 1/2 backfill, water thoroughly before placing remainder of backfill. Repeat watering until no more is absorbed. Water again after placing and tamping final layer of backfill.

3.8 TREE AND SHRUB PRUNING

- A. Prune, thin, and shape trees and shrubs according to standard horticultural practice. Prune trees to retain required height and spread. Unless otherwise directed by Owner's Representative, do not cut tree leaders; remove only injured or dead branches from flowering trees. Prune shrubs to retain natural character. Shrub sizes indicated are size after pruning.

3.9 TREE AND SHRUB GUYING AND STAKING

- A. Upright Staking and Tying: Stake trees of 2 through 5 inch (50 through 125 mm) caliper. Stake trees of less than 2 inch (50 mm) caliper only as required to prevent wind tip-out. Use a minimum of 2 stakes of length required to penetrate at least 18 inches (450 mm) below bottom of backfilled excavation and to extend at least 72 inches (1800 mm) above grade. Set vertical stakes and space to avoid penetrating balls or root masses. Support trees with 2 strands of tie wire encased in hose sections at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.

- B. Guying and Staking: Guy and stake trees exceeding 14 feet (4.2 m) and more than 3 inch (75 mm) caliper unless otherwise indicated. Securely attach no fewer than 3 guys to stakes 30 inches (760 mm) long, driven to grade. Attach flags to each guy wire, 30 inches (760 mm) above finish grade.

3.10 PLANTING GROUND COVER AND PLANTS

- A. Space ground cover and plants as indicated.
- B. Space ground cover and plants not more than 24 inches (600 mm) apart.
- C. Dig holes large enough to allow spreading of roots, and backfill with planting soil. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

3.11 MULCHING

- A. Mulch backfilled surfaces of pits, trenches, planted areas, and other areas indicated.
- B. Organic Mulch: Apply the following average thickness of organic mulch and finish level with adjacent finish grades. Do not place mulch on trunks or stems.
 - 1. Thickness: 4 inches (75 mm).Width: 6 foot diameter around trees not in planting beds.

3.12 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.

3.13 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Remove surplus soil and waste material, unsuitable soil, trash, and debris, and legally dispose of it off the Owner's property.

END OF SECTION 32 93 00

SECTION 33 41 00 - STORM DRAINAGE 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 storm drainage outside the building.
- B. Related Sections include the following:
 - 1. Division 33 Section "Subdrainage" for foundation drains connecting to storm drainage.

1.3 DEFINITIONS

- A. RCP: Reinforced concrete pipe and fittings.
- B. PVC: Polyvinyl chloride plastic pipe and fittings.
- C. HDPE: High density polyethylene plastic pipe and fittings.

1.4 PERFORMANCE REQUIREMENTS

- A. Gravity-Flow, Nonpressure-Piping Pressure Ratings: At least equal to system test pressure.

1.5 SUBMITTALS

- A. Product Data: For the following:
 - 1. Pipe and fittings.
 - 2. Polymer-concrete, channel drainage systems.
 - 3. Plastic drainage system components.
 - 4. Backwater valves, cleanouts, and drains.
- B. Shop Drawings: Include plans, elevations and details for the following:
 - 1. Precast concrete manholes and other structures, including frames, covers, and grates.
 - 2. Cast-in-place concrete structures, including frames, covers, and grates.
- C. Design Mix Reports and Calculations: For each class of cast-in-place concrete.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic structures, pipe, and fittings in direct sunlight.
- B. Protect pipe, pipe fittings, and seals from dirt and damage.
- C. Handle precast concrete manholes and other structures according to manufacturer's written rigging instructions.

1.7 PROJECT CONDITIONS

- A. Site Information: Review in the field to verify existing utility locations. Notify "Miss Utility" (telephone: 1-800-257-7777) for field marking of existing utilities before commencement of Work.
- B. Locate existing structures and piping to be closed and abandoned.
- C. 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's Representative not less than two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Owner's Representative's written permission.

1.8 QUALITY ASSURANCE

- A. Material and Installation Specifications; Maryland Department of Transportation, State Highway Administration (MSHA) Standard Specifications for Construction and Materials, February 2001, as amended to date. Delete references to "Measurement and Payment".
- B. Standard Details: Maryland Department of Transportation, State Highway Administration (MSHA) Standard Specifications for Construction and Materials, February 2001, as amended to date.
- C. Baltimore County Plumbing Code, as amended to date.

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. Polymer-Concrete, Channel Drainage Systems:
 - a. ABT, Inc.
 - b. ACO Polymer Products, Inc.
 - c. Josam Co.; Mea-Josam Div.

2. Gray-Iron Backwater Valves, Cleanouts, and Drains:

- a. Josam Co.
- b. McWane, Inc.; Tyler Pipe; Wade Div.
- c. MIFAB.
- d. Smith: Jay R. Smith Mfg. Co.
- e. Watts Industries, Inc.; Ancon Drain Div.
- f. Watts Industries, Inc.; Enpoco, Inc. Div.
- g. Zurn Industries, Inc.; Hydromechanics Div.

3. PVC Backwater Valves and Cleanouts:

- a. Canplas, Inc.
- b. IPS Corp.
- c. NDS, Inc.
- d. Plastic Oddities, Inc.
- e. Sioux Chief Manufacturing Co., Inc.

2.2 PIPING MATERIALS

- A. Refer to Part 3 for applications of pipe and fitting materials.

2.3 PIPES AND FITTINGS

- A. Hub-and-Spigot, Cast-Iron Soil Pipe and Fittings: ASTM A 74, gray iron, for gasketed joints.

1. Gaskets: ASTM C 564, rubber, compression type, thickness to match class of pipe.

- B. Corrugated-Steel Pipe: ASTM A 760/A 760M, Type I, made from ASTM A 929/A 929M, zinc-coated steel sheet for banded joints.

1. Fittings: Fabricated to types indicated and according to same standards as pipe.
2. Connecting Bands: Standard couplings made for corrugated-steel pipe to form soiltight joints.

- C. Corrugated PE Smooth Interior Drainage Pipe and Fittings: AASHTO M 252, Type S (4 to 10-inch); AASHTO M 294, Type S (12 to 30-inch), with smooth interior waterway and annular exterior corrugations.

1. Soiltight Couplings: AASHTO M 252, corrugated, matching tube and fittings to form soiltight joints.
2. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with tube and fittings to form silttight joints.

- D. Corrugated PE Drainage Tubing and Fittings: AASHTO M 252, Type C (4 to 10-inch); AASHTO M 294, Type C (12 to 24-inch) with annular interior and exterior corrugations.

1. Soiltight Couplings: AASHTO M 294, corrugated, matching pipe and fittings to form soiltight joints.
2. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with pipe and fittings to form silttight joints.

- E. PVC Pipe and Fittings: In accordance with Baltimore Plumbing Code and the following:
 - 1. PVC Pipe and Fittings, (Schedule 40 or heavier) Pipe and Fabricated Fittings, NPS 4 to 15-inch, for solvent-cemented or gasketed joints.
 - a. Gaskets: ASTM F 477, elastomeric seals.
 - 2. PVC Pipe and Fittings, NPS 18 and Larger: ASTM F 679, T-1 wall thickness, bell and spigot for gasketed joints.
 - a. Gaskets: ASTM F 477, elastomeric seals.
- F. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76, Class IV as indicated on the drawings, Wall B, for gasketed joints.
 - 1. Gaskets: ASTM C 443, rubber.

2.4 SPECIAL PIPE COUPLINGS AND FITTINGS

- A. Sleeve-Type Pipe Couplings: ASTM C 1173, rubber or elastomeric sleeve and band assembly fabricated to mate with OD of pipes to be joined, for nonpressure joints.
 - 1. Sleeve Material for Concrete Pipe: ASTM C 443, rubber.
 - 2. Sleeve Material for Cast-Iron Soil Pipe: ASTM C 564, rubber.
 - 3. Sleeve Material for Plastic Pipe: ASTM F 477, elastomeric seal.
 - 4. Sleeve Material for Dissimilar Pipe: Compatible with pipe materials being joined.
 - 5. Bands: Stainless steel, at least one at each pipe insert.
- B. Bushing-Type Pipe Couplings: ASTM C 1173, rubber or elastomeric bushing fabricated to mate with OD of smaller pipe and ID of adjoining larger pipe, for nonpressure joints.
 - 1. Material for Concrete Pipe: ASTM C 443, rubber.
 - 2. Material for Cast-Iron Soil Pipe: ASTM C 564, rubber.
 - 3. Material for Plastic Pipe: ASTM F 477, elastomeric seal.
 - 4. Material for Dissimilar Pipe: Compatible with pipe materials being joined.

2.5 MANHOLES

- A. Heavy-Traffic Bearing Precast Concrete Manholes: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for rubber gasketed joints, in accordance with *MSHA* standard details and specifications, and as shown on the drawings.
 - 1. Diameter: 48 inches minimum, unless otherwise indicated.
 - 2. Base Section: 5-inch minimum thickness for walls and base riser section, with integral 8" minimum thick base slab.
 - 3. Riser Sections: 5-inch minimum thickness, 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. Gaskets: ASTM C 443, rubber.
 - 6. Grade Rings: Include two or three reinforced-concrete rings, of 6- to 9-inch total thickness, or brick, that match 24-inch- diameter frame and cover.

7. Steps: Material and placement shall be in accordance with *MSHA* standard details and specifications.
 8. Pipe Connectors: ASTM C 923, resilient, of size required for each pipe connecting to base section.
- B. Manhole Frames and Covers in accordance with *MSHA* standard details and specifications, designed for heavy-duty service. Include top design with lettering cast into cover.
- C. Brick Manholes: in accordance with *MSHA* standard details and specifications, designed for heavy-traffic bearing service.
- D. Cast-in-Place Concrete Manholes: in accordance with *MSHA* standard details and specifications, designed for heavy-traffic bearing service.

2.6 INLETS

- A. Heavy-Traffic Bearing Precast Concrete Inlets: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for rubber gasketed joints, in accordance with *MSHA* standard details and specifications.
1. Base Section: 6-inch minimum thickness for walls and base riser section, with integral 6" minimum thick base slab.
 2. Riser Sections: 6-inch minimum thickness, and lengths to provide depth indicated.
 3. Gaskets: ASTM C 443, rubber.
 4. Steps: Material and placement shall be in accordance with *MSHA* standard details and specifications.
 5. Pipe Connectors: ASTM C 923, resilient, of size required for each pipe connection.
- B. Heavy-Traffic Bearing Frames and Grates: in accordance with *MSHA* specifications, designed for heavy-traffic bearing service.
- C. Cast-in-Place Concrete Inlets: in accordance with *MSHA* standard details and specifications, designed for heavy-traffic bearing service.
- D. Headwalls, Endwalls and End Sections: in accordance with *MSHA* standard details and specifications

2.7 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. Portland Cement Design Mix: 4500 psi minimum, with 0.45 maximum water-cementitious ratio.
1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
 2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.

2.8 BACKWATER VALVES

- A. Gray-Iron Backwater Valves: ASME A112.14.1, gray-iron body and bolted cover, with bronze seat.
 - 1. Horizontal Type: With swing check valve and hub-and-spigot ends.
 - 2. Combination Horizontal and Manual Gate-Valve Type: With swing check valve, integral gate valve, and hub-and-spigot ends.
 - 3. Terminal Type: With bronze seat, swing check valve, and hub inlet.
- B. PVC Backwater Valves: Similar to ASME A112.14.1, horizontal type; with PVC body, PVC removable cover, and PVC swing check valve.

2.9 CLEANOUTS

- A. Gray-Iron Cleanouts: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-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, and in accordance with *MSHA* standard details and specifications:
 - 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.
- B. PVC Cleanouts: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping, and in accordance with *MSHA* standard details and specifications.

PART 3- EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earthwork."

3.2 IDENTIFICATION

- A. Materials and their installation are specified in Division 31 Section "Earthwork." Arrange for installing green warning tapes directly over piping and at outside edges of underground structures.
 - 1. Use warning tape or detectable warning tape over ferrous piping.
 - 2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.3 PIPING APPLICATIONS

- A. General: Include watertight, silt-tight, or soil-tight joints, unless watertight or silt-tight joints are indicated.

- B. Refer to Part 2 of this Section for detailed specifications for pipe and fitting products listed below. Use pipe, fittings, and joining methods according to applications indicated.
- C. Gravity-Flow Piping: Use the following, with type and class as indicated on the drawings:
1. NPS 3: Hub-and-spigot, Extra-Heavy class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 2. NPS 4 to NPS 6: Hub-and-spigot, Extra-Heavy class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 3. NPS 4 and NPS 6: ABS, SDR 35, sewer pipe and fittings; solvent-cemented joints; or gaskets and gasketed joints.
 4. NPS 4 and NPS 6: Corrugated PE drainage tubing and fittings, soiltight couplings, and coupled joints.
 5. NPS 4 and NPS 6: Corrugated PE drainage tubing and fittings, silttight couplings, and coupled joints.
 6. NPS 4 and NPS 6: PVC sewer pipe and fittings, solvent-cemented joints, or gaskets and gasketed joints.
 7. NPS 8 to NPS 15: Hub-and-spigot, Extra-Heavy class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 8. NPS 8 to NPS 15: ABS, SDR 35, sewer pipe and fittings; solvent-cemented joints; or gaskets and gasketed joints in NPS 8 to NPS 12. Use PVC sewer pipe and fittings, solvent-cemented joints, or gaskets and gasketed joints in NPS 15.
 9. NPS 8 to NPS 30: Smooth interior, corrugated exterior PE drainage pipe, and tubing, and fittings, silt-tight couplings, and coupled joints in NPS 8 to NPS 30.
 10. NPS 8 to NPS 36: PVC sewer pipe and fittings, solvent-cemented joints, or gaskets and gasketed joints.
 11. NPS 18 to NPS 42: Reinforced-concrete sewer pipe and fittings, gaskets, and gasketed joints.
 12. NPS 18 to NPS 36: Reinforced-concrete arch pipe, sealing bands, and banded joints.
 13. NPS 18 to NPS 36: Reinforced-concrete, elliptical pipe, Type HE, horizontal; sealing bands; and banded joints.
 14. NPS 18 to NPS 36: Reinforced-concrete, elliptical pipe, Type VE, vertical; sealing bands; and banded joints.
 15. NPS 42 to NPS 144: Reinforced-concrete sewer pipe and fittings, gaskets, and gasketed joints.
 16. NPS 42 to NPS 132: Reinforced-concrete arch pipe, sealing bands, and banded joints.

3.4 SPECIAL PIPE COUPLING AND FITTING APPLICATIONS

- A. Special Pipe Couplings: Use where required to join piping and no other appropriate method is specified. Do not use instead of specified joining methods.
1. Use the following pipe couplings for nonpressure applications:
 - a. Sleeve type to join piping, of same size, or with small difference in OD.
 - b. Increaser/reducer-pattern, sleeve type to join piping of different sizes.
 - c. Bushing type to join piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.

3.5 INSTALLATION, GENERAL

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical, and in accordance with *MSHA* Specifications
- B. Install piping beginning at low point, 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 written instructions 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. Install manholes at changes in direction, unless fittings are indicated. Use fittings for branch connections, unless direct tap into drain is indicated.
- D. Use proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
- E. Install gravity-flow piping and connect to building's storm drains, of sizes and in locations indicated. Temporarily terminate piping if indicated.
- F. Extend storm drainage piping and connect to building's storm drains, of sizes and in locations indicated. Temporarily terminate piping if indicated.

3.6 PIPE JOINT CONSTRUCTION AND INSTALLATION

- A. General: Join and install pipe and fittings according to installations indicated and in accordance with *MSHA* standard details and specifications.
- B. Hub-and-Spigot, Cast-Iron Soil Pipe and Fittings: With rubber gaskets according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook." Use gaskets that match class of pipe and fittings.
- C. Install with top surfaces of cleanouts flush with finished surface of paving.
- D. ABS Pipe and Fittings: As follows:
 - 1. Join pipe and gasketed fittings with gaskets according to ASTM D 2321.
 - 2. Install according to ASTM D 2321.
- E. PE Pipe and Fittings: As follows:
 - 1. Join pipe, tubing, and fittings with couplings for soiltight joints according to manufacturer's written instructions.
 - 2. Install according to ASTM D 2321 and manufacturer's written instructions.
 - 3. Install corrugated piping according to the manufacturer's recommendations and the Corrugated Polyethylene Pipe Association's "Recommended Installation Practices for Corrugated Polyethylene Pipe and Fittings."
- F. PVC Sewer Pipe and Fittings: As follows:
 - 1. Join pipe and gasketed fittings with gaskets according to ASTM D 2321.

2. Install according to ASTM D 2321.

G. Concrete Pipe and Fittings: Install in accordance with *MSHA* specifications Section 303. Use the following seals:

1. Round Pipe and Fittings: ASTM C 443, rubber gaskets.

H. System Piping Joints: Make joints using system manufacturer's couplings, unless otherwise indicated.

I. Join piping made of different materials or dimensions with couplings made for this application. Use couplings that are compatible with and that fit both systems' materials and dimensions.

3.7 MANHOLE INSTALLATION

A. General: Install manholes, complete with appurtenances and accessories indicated, and in accordance with *MSHA* standard details and specifications.

B. Construct continuous channels and benches between inlets and outlet.

C. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops flush with finish grade elsewhere, unless otherwise indicated.

D. Install precast concrete manhole sections with gaskets according to ASTM C 891.

3.8 STORM DRAIN INLET INSTALLATION

A. Construct inlets as indicated on the drawings and in accordance with *MSHA* standard details and specifications.

3.9 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 318 and ACI 350R.

3.10 BACKWATER VALVE INSTALLATION

A. Install horizontal units in piping where indicated, and in accordance with manufacturer's recommendations.

B. Install combination units in piping and in structures where indicated.

C. Install terminal units on end of piping and in structures where indicated. Secure units to structure walls.

3.11 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 storm drain pipe.

- B. Set cleanout frames and covers in lawn and plant bed areas in cast-in-place concrete block, 18 by 18 by 12 inches deep. Set with tops 1 inch above surrounding earth grade.
- C. Set cleanout frames and covers in concrete pavement with tops flush with pavement surface.

3.12 TAP CONNECTIONS

- A. Make connections to existing piping and underground structures so finished Work complies as nearly as practical with requirements specified for new Work.
- B. Use commercially manufactured wye fittings for piping branch connections, where possible. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting, plus 6-inch overlap, with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
- C. Make branch connections from side into existing reinforced concrete piping, or into manhole and inlet structures by cutting opening into existing unit large enough to allow 3 inches of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall, unless otherwise indicated. On outside of pipe or structure wall, encase entering connection in 6 inches of concrete for minimum length of 12 inches to provide additional support of collar from connection to undisturbed ground.
 - 1. Use concrete that will attain minimum 28-day compressive strength of 3000 psi, unless otherwise indicated.
- D. Protect existing piping and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

3.13 CLOSING ABANDONED STORM DRAINAGE SYSTEMS

- A. Abandoned Piping: Close open ends of abandoned underground piping 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 procedure below:
 - 1. Close open ends of piping with at least 8-inch- thick, brick masonry bulkheads or concrete if the pipe is 12' diameter or less.
 - 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 one procedure below, or as indicated on the drawings:
 - 1. Remove structure and close open ends of remaining piping.
 - 2. Remove top of structure down to at least 36 inches below final grade. Fill to within 12 inches of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.
 - 3. Backfill to grade according to Division 31 Section "Earthwork."

3.14 FIELD QUALITY CONTROL

- A. Clear interior of piping and structures of dirt and superfluous material as 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 when work stops.
 - 3. Flush piping between manholes and other structures to remove collected debris, if required by authorities having jurisdiction.

- 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 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 visible between structures.
 - b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of 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 inspections by authorities having jurisdiction with at least 24 hours' advance notice.
 - 4. Submit separate reports for each test.
 - 5. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

END OF SECTION 33 41 00

SECTION 33 46 00 - SUBDRAINAGE

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. Perforated-wall pipe and fittings.
 - 2. Geotextile filter fabrics.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. Geotextile filter fabrics.

PART 2 - PRODUCTS

2.1 PERFORATED-WALL PIPES AND FITTINGS

- A. Perforated PE Pipe and Fittings:
 - 1. NPS 6 and Smaller: ASTM F 405 or AASHTO M 252, Type CP; corrugated, for coupled joints.
 - 2. NPS 8 and Larger: ASTM F 667; AASHTO M 252, Type CP; or AASHTO M 294, Type CP; corrugated; for coupled joints.
 - 3. Couplings: Manufacturer's standard, band type.

2.2 SOIL MATERIALS

- A. Soil materials are specified in Division 31 Section "Earthwork."

2.3 GEOTEXTILE FILTER FABRICS

- A. Description: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. when tested according to ASTM D 4491.
- B. Structure Type: Nonwoven, needle-punched continuous filament.

1. Survivability: AASHTO M 288 Class 2.
2. Styles: Flat and sock.

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

3.2 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earthwork."

3.3 LANDSCAPING DRAINAGE INSTALLATION

- A. Provide trench width to allow installation of drainage conduit. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.
- 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.
- D. Install drainage conduits as indicated in Part 3 "Piping Installation" Article for landscaping subdrainage with horizontal distance of at least 6 inches between conduit and trench walls. Wrap drainage conduits without integral geotextile filter fabric with flat-style geotextile filter fabric before installation. Connect fabric sections with adhesive or tape.
- E. Add drainage course to top of drainage conduits.
- F. After satisfactory testing, cover drainage conduit to within 12 inches of finish grade.
- G. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.
- H. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 inches.
- I. Fill to Grade: Place satisfactory soil fill material over drainage course. Place material in loose-depth layers not exceeding 6 inches. Thoroughly compact each layer. Fill to finish grade.

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 according to manufacturer's written instructions and other requirements indicated.
 - 1. Landscaping Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 1.0 percent and with a minimum cover of 10 inches 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.

3.5 PIPE JOINT CONSTRUCTION

- A. Join perforated PE pipe and fittings with couplings according to ASTM D 3212 with loose banded, coupled, or push-on joints.
- B. Join perforated PVC sewer pipe and fittings according to ASTM D 3212 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 IDENTIFICATION

- A. Arrange for installation of green warning tapes directly over piping. Comply with requirements for underground warning tapes specified in specified in Division 31 Section "Earthwork."
 - 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.

3.7 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.

3.8 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 33 46 00