PROJECT MANUAL
VOLUME 2 (DIVISIONS 22-33)

NEW ANIMAL SHELTER

225 MAPLE AVENUE
MONTVILLE, CT 06791

Issued for Bid: October 25, 2023

S/P+ A Project No. 22.130

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SECTION 220100 - GENERAL CONDITIONS FOR PLUMBING TRADE

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. General Conditions, Supplementary Conditions and Division 01 paragraphs may be repeated in this Division for emphasis or for inclusion of more stringent/additional related requirements. Such repetition shall not be construed to reduce the requirements of those Divisions nor to eliminate other requirements under those Divisions.

1.2 DESCRIPTION

A. The General Conditions are a part of this Division and are to be considered a part of this Contract.

B. Where items of the General Conditions are repeated in other Sections of the Specifications, it is merely intended to qualify or to call particular attention to them. It is not intended that any other parts of the General Conditions shall be assumed to be omitted if not repeated therein.

C. This Section applies equally and specifically to all Contractors supplying labor and/or equipment and/or materials as required under each Section of Division 22.

D. The following information contains specifications of Work in connection with, and in addition to, this Division:

1. All drawings associated with the project.
2. All specifications associated with the project.

E. Divisions of work responsibilities shall be defined and directed by the Construction Manager.

1.3 INTENT

A. It is the intent of the Specifications and Drawings to call for finished work, tested and ready for operation.

B. Furnish, deliver, and install any apparatus, appliance, material, or Work not shown on Drawings but mentioned in the Specifications, or vice versa, or any incidental accessories necessary to make the Work complete and perfect in all respects and ready for operation, even if not particularly specified, under their respective Section without additional expense to the Owner.

C. Include in the work minor details not usually shown or specified but necessary for proper installation and operation, as though they were hereinafter shown or specified.

D. Provide Engineer written notice of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules, or regulations of authorities having jurisdiction; and any necessary items of Work omitted. In the absence of such written notice, it is mutually agreed that Work under each Section has included the cost of all required items for the accepted, satisfactory functioning of the entire system without extra compensation.

E. The Work indicated is diagrammatic. The Architect and/or Engineer may require as part of this Contract, the relocation of devices to reasonable distances from the general locations shown.

F. Verbal clarifications of the Drawings or Specifications during the bid period are not to be relied upon.

1.4 DRAWINGS

A. Drawings are diagrammatic and indicate the general arrangement of systems and work included in the Contract. (Do not scale the Drawings.) Consult the Architectural Drawings and Details for exact location of fixtures and equipment; where same are not definitely located, obtain this information from the Architect.

B. Closely follow Drawings in layout of Work; check Drawings of other Divisions to verify spaces in which work will be installed. Maintain maximum headroom. Where space conditions appear inadequate, Engineer shall be notified before proceeding with installations.

C. Engineer may, without extra charge, make reasonable modifications in the layout as needed to prevent conflict with work of other trades and/or for proper execution of the work.

1.5 SURVEYS AND MEASUREMENTS

A. Before submitting a Bid, the Contractor shall visit the site and shall become thoroughly familiar with all conditions under which the work will be installed. Contractor will be held responsible for any assumptions, omissions, or errors made as a result of failure to become familiar with the site and the Contract Documents.

B. Base all measurements, both horizontal and vertical, from established benchmarks. All Work shall agree with these established lines and levels. Verify all measurements at the site and check the correctness of same as related to the Work.

C. Should the Contractor discover any discrepancies between actual measurements and those indicated which prevent following good practice or the intent of the Drawings and Specifications, notify the Engineer do not proceed with that Work until instructions have been received from the Engineer.

1.6 CODES AND STANDARDS

A. The Codes and Standards listed below apply to all Work. Where Codes or Standards are mentioned in these Specifications, follow the latest edition or revision.

B. The current adopted editions of the following State or local Codes apply:

2022 Connecticut State Building Code (CSBC)
2021 International Building Code
2022 Connecticut State Fire Code
2021 NFPA 101 Life Safety Code (NFPA101)
2022 Connecticut Fire Prevention Code (CFPC)
2015 NFPA 1 Fire Code (NFPA101)
2021 International Plumbing Code and referenced publications
2021 International Mechanical Code and referenced publications
NFPA 54/2015, National Fuel Gas Code
NFPA 70/2020, National Electrical Code
NFPA 72/2013, National Fire Alarm Code
AWWA Standards

Factory Mutual Approval Guide: latest edition.
Pipe Hangers and Supports: MSS SP-58.
UL Compliance.
The American National Standards Institute (ANSI) A117.1/2009
Local Building Code

C. The following Standards shall be used where referenced by the following abbreviations:

AABC Associated Air Balance Council
ACGIH American Conference of Governmental Industrial Hygienists
ADC Air Diffusion Council
AGA American Gas Association
AIA American Institute of Architects
AMCA Air Moving and Conditioning Association
ANSI American National Standards Institute
API American Petroleum Institute
ARI Air Conditioning and Refrigeration Institute
ASE Association of Safety Engineers
ASHRAE American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME American Society of Mechanical Engineers
ASPE American Society of Plumbing Engineers
ASTM American Society of Testing and Materials
AWS American Welding Society
AWWA American Water Works Association
CGA Compressed Gas Association
CSA Canadian Standards Association
CISPI Cast Iron Soil Pipe Institute
EJMA Expansion Joint Manufacturing Association
EPA Environmental Protection Agency
FM Factory Mutual Insurance Association
FSSC Federal Specification
HIS Hydraulic Institute Standards
IBR Institute of Boiler and Radiator Manufacturers
IEEE Institute of Electrical and Electronics Engineers
IRI Industrial Risk Insurers
ISO Insurance Services Office
MCAA Mechanical Contractors Association of America
MSS Manufacturers Standardization Society
NBS National Bureau of Standards
NEBB National Environmental Balancing Bureau
NEMA National Electrical Manufacturers Association
NFPA National Fire Protection Association
NOFI National Oil Fuel Institute
NRC National Research Council
NSC National Safety Council
NSF National Sanitation Foundation
OSHA Occupational Safety and Health Administration
PDI Plumbing and Drainage Institute
SAMA Scientific Apparatus Manufacturers Association
SBI Steel Boiler Industry (Division of Hydronics Institute)
SMACNA Sheet Metal and Air Conditioning Contractors National Association
STI Steel Tank Institute
UL Underwriters' Laboratories

D. All materials furnished and all work installed shall comply with the rules and recommendations of the NFPA, the requirements of the local utility companies, the recommendations of the fire

insurance rating organization having jurisdiction, and the requirements of all Governmental departments having jurisdiction.

E. Include in the Work, without extra cost to the Owner, any labor, materials, services, apparatus, and Drawings in order to comply with all applicable laws, ordinances, rules, and regulations, whether or not shown on Drawings and/or specified.

1.7 SEISMIC RESTRAINT

A. General: This project is in a seismic zone per State and/or Local Codes and Ordinances and all materials and equipment shall be installed, supported, and seismically restrained accordingly. Verify current seismic requirements based on project location and with Code requirements.

B. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in the jurisdiction where the Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of vibration isolation bases and seismic restraints that are similar to those required for this Project in material, design, and extent.

C. Shop Drawings: Show designs and calculations, certified by a professional engineer, for the following:

1. Design Calculations: Calculations for selection of vibration isolators, design of vibration isolation bases, design of seismic supports, and selection of seismic restraints for all equipment and materials.
2. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to the structure and to the supported equipment. Include auxiliary motor slides and rails, and base weights.
3. Seismic Restraint Details: Detail fabrication and attachment of restraints, supports, and snubbers.

D. Installation: Installation shall be carried out in strict accordance with the Seismic Engineer's submittal, current Code, accepted standards, and the equipment and material manufacturers' recommendations.

1.8 COORDINATION

A. Carry out all work in conjunction with other trades and give full cooperation in order that all Work may proceed with a minimum of delay and interference. Particular emphasis is placed on timely installation of major apparatus and furnishing other Contractors, especially the General Contractor or Construction Manager, with information as to openings, chases, sleeves, bases, inserts, equipment locations, panels, access doors, etc. required by other trades.

B. Contractors are required to examine all the Project Drawings and mutually arrange Work so as to avoid interference. In general, ductwork, heating piping, sprinkler piping, and drainage lines take precedence over water, gas, and electrical conduits. The Engineer regarding the arrangement of Work, which cannot be agreed upon by the Contractors, will make final decisions.

C. Where the Work of the Contractor will be installed in close proximity to or will interfere with Work of other trades, assist in working out space conditions to make a satisfactory adjustment.

D. If Work is installed before coordinating with other Divisions or so as to cause interference with Work of other Sections, the Contractor causing the interference will make necessary changes to correct the condition without extra charge to the Owner.

E. Initial contact and coordination have been conducted with utility entities for the purpose of the preparation of Bid Documents. The Contractor shall coordinate all final specific utility requirements.

1.9 ACCEPTANCES

A. The equipment, materials, Workmanship, design, and arrangement of all Work installed are subject to the review of the Engineer.

B. Within thirty (30) days after the awarding of a Contract, submit to the Engineer for review a list of manufacturers of equipment proposed for the Work. The intent to use the exact makes specified does not relieve the Contractor of the responsibility of submitting such a list.

1. If extensive or unacceptable delivery time is expected on a particular item of equipment specified, notify the Engineer, in writing, within thirty (30) days of the awarding of the Contract. In such instances, deviations may be made pending acceptance by the Engineer or the Owner's representative.

C. Where any specific material, process, or method of construction or manufactured article is specified by reference to the catalog or model number of a manufacturer, the Specifications are to be used as a guide and are not intended to take precedence over the basic duty and performance specified or noted on the Drawings. In all cases, verify the duty specified with the specific characteristics of the equipment offered for review. Equipment characteristics are to be used as mandatory requirements where the Contractor proposes to use an acceptable equivalent.

D. If material or equipment is installed before shop drawing review, liability for its removal and replacement is assumed by the Contractor, at no extra charge to the Owner, if, in the opinion of the Engineer, the material or equipment does not meet the intent of the Drawings and Specifications.

E. Failure on the part of the Engineer to reject shop drawings or to reject Work in progress shall not be interpreted as acceptance of Work not in conformance with the Drawings and/or Specifications. Correct Work not in conformance with the Drawings and/or Specifications whenever non-conformance is discovered.

1.10 EQUIPMENT DEVIATIONS

A. Refer to Section 016000 “Product Requirements”.

B. In these Specifications and on the accompanying Drawings, one (1) or more makes of materials, apparatus, or appliances may have been specified for use in this installation. This has been done for convenience in fixing the standard of workmanship, finish, and design required for installation. In the event that only one (1) manufacturer of a product is specified, and it is found that the manufacturer has discontinued the product, the Contractor shall use an acceptable equivalent product that meets the requirements of an equivalent product, as noted below, and has all the features of the originally specified product. The details of workmanship, finish, and design, and the guaranteed performance of any material, apparatus, or appliance which the Contractor desires to deviate for those mentioned herein shall also conform to these standards.

C. Where no specific make of material, apparatus, or appliance is mentioned, any first-class product made by a reputable manufacturer may be submitted for the Engineer's review.

D. Equipment, material, or devices submitted for review as an "accepted equivalent" shall meet the following requirements:

1. The equivalent shall have the same construction features such as, but not limited to:

a. Material thickness, gauge, weight, density, etc.
b. Welded, riveted, bolted, etc., construction.
c. Finish, undercoatings, corrosion protection.

2. The equivalent shall perform with the same or better operating efficiency.
3. The equivalent shall have equal or greater reserve capacity.
4. The equivalent shall be locally represented by the manufacturer for service, parts, and technical information.
5. The equivalent shall bear the same labels of performance certification as is applicable to the specified item, such as AMCA or ARI labels.

E. Where the Contractor proposes to use an item of equipment other than specified or detailed on the Drawings which requires any redesign of the structure, partitions, foundations, piping, wiring, or any other part of the mechanical, electrical, or architectural layout, all such redesign and all new drawings and detailing required therefore shall be prepared by the Designers of Record at the expense of the Contractor and at no additional cost to the Owner.

F. Where such accepted deviation or substitution requires a different quantity and arrangement of piping, ductwork, valves, pumps, insulation, wiring, conduit, and equipment from that specified or indicated on the Drawings, the Contractor shall, with the acceptance by the Engineer, furnish and install any such additional equipment required by the system at no additional cost to the Owner, including any costs added to other trades due to the substitution.

G. The Engineer shall determine if an "accepted equivalent" to a manufacturer listed in the Specifications is considered acceptable.

1.11 SHOP DRAWINGS

A. Refer to Section 013300 “Submittal Procedures” as well as individual specification sections for additional submittal information.

B. All plumbing submittals shall be submitted in a single package. “Piece-Meal” or “Partial” submittals will not be accepted, and will be rejected and returned without review, unless prior approval from the Engineer has been obtained. NO EXCEPTIONS.

C. Plumbing long lead items are excluded from requirement but must be submitted complete in their entirety by specification section, when provided.

D. The Contractor shall submit for review detailed shop drawings of all equipment and material specified in each section and coordinated ductwork layouts. No material or equipment may be delivered to the job site or installed until the Contractor has received shop drawings for the particular material or equipment which have been properly reviewed.

E. Provide shop drawings for all devices specified under equipment specifications for all systems, materials, equipment, and/or devices. Shop drawings shall include manufacturers' names, catalog numbers, cuts, diagrams, and other such descriptive data as may be required to identify and accept the equipment. A complete list in each category (example: all fixtures) of all shop drawings, catalog cuts, material lists, etc., shall be submitted to the Engineer at one (1) time. No consideration will be given to a partial shop drawing submittal.

1. Equipment shop drawings shall contain full range performance curves, graphs, tables, or other pertinent data which clearly indicates operational range of a given unit size. Computer generated/plotted curves, based solely on design performance, will not be accepted.
2. All specific options and/or alternatives shall be clearly indicated. Failure to do so shall be grounds for rejection.

F. Submittals shall be marked with the trade involved, i.e., HVAC, plumbing, fire protection, etc. and the specific associated specification section.

G. Where multiple quantities or types of equipment are being submitted, provide a cover sheet (with a list of contents) on the submittal identifying the equipment or material being submitted.

H. The Contractor shall furnish all necessary templates, patterns, etc., for installation work and for the purpose of making adjoining work conform; furnish setting plans and shop details to other trades as required.

I. Acceptance rendered on shop drawings shall not be considered as a guarantee of measurements or building conditions. Where drawings are reviewed, review does not indicate that drawings have been checked in detail; said approval does not in any way relieve the Contractor from his responsibility or necessity of furnishing material or performing work as required by the Contract Drawings and Specifications. Verify available space prior to submitting shop drawings.

J. Acceptance of shop drawings shall not apply to quantity nor relieve Contractor of his responsibility to comply with intent of Drawings and Specifications.

K. Acceptance of shop drawings is final and no further changes will be allowed without the written consent of the Engineer.

L. Shop drawing submittal sheets which may show items that are not being furnished shall have those items crossed off to clearly indicate which items will be furnished.

M. Conform the plumbing work to the requirements herein. Provide offsets, fittings, drains, and accessories which may be required to accommodate structural, HVAC, plumbing, existing conditions, etc. Investigate the structural and finish conditions affecting the work and arrange the work accordingly. Provide such piping, fittings, valves, and accessories as may be required to meet such conditions.

1.12 CHANGES IN WORK

A. Change Order is a written order to the Contractor signed by the Owner and the Architect, issued after Contracts have been awarded, authorizing a change in the work or an adjustment in the Contract sum or the Contract time. A Change Order signed by the Contractor indicates his agreement therewith, including the adjustment in the Contract sum or the Contract time.

B. All changes in the work shall follow the recommendations of the AIA "General Conditions of the Contract for Construction", Article 7.

1.13 MANUFACTURER'S IDENTIFICATION

A. All component parts of each item of equipment or device shall bear the manufacturer's nameplate giving name of manufacturer, description, size, type, serial and model number, electrical characteristics, etc., in order to facilitate maintenance or replacement. The nameplate of a Contractor or distributor will not be acceptable.

B. All material and equipment for the electrical portion of the mechanical systems shall bear the label of or be listed by UL, or other accredited authoritative agencies or testing organizations approved by the authority having jurisdiction.

1.14 RECORD DRAWINGS

A. Refer to Section 017700 “Project Record Documents”.

B. Maintain at the job site a record set of Mechanical Drawings on which any changes in location or routing of all equipment, materials and access panels shall be recorded.

C. At the end of construction, the Contractor shall provide the Owner with a complete set of As-Built Drawings, including all updated coordination drawings, ductwork, and piping plans. Prepare As-Built documentation utilizing the most recent version of AutoCAD. Provide the Owner with a “CD ROM” disk and one (1) set of reproducible documents.

D. If electronic copies of the contract documents are made available to the Contractor for use in production of As-Built documentation, the Contractor assumes responsibility for completeness and accuracy of the As-Built documents. Translation or manipulation of electronic documents provided to the Contractor is the responsibility of the Contractor.

1.15 MATERIALS AND WORKMANSHIP

A. All materials and apparatus required for the work, except as otherwise specifically indicated, shall be new, of first-class quality, and shall be furnished, delivered, erected, connected, and finished in every detail and be so selected and arranged as to fit properly into the building spaces. Where no specific type or quality of material is given, a first-class standard article as accepted by industry standards shall be furnished.

B. The Contractor shall furnish the services of an experienced superintendent who shall be constantly in charge of the installation of the work together with all skilled workmen, fitters, metal workers, welders, helpers, and laborers required to unload, transfer, erect, connect, adjust, start, operate, and test each system.

C. Unless otherwise specifically indicated on the Drawings or Specifications, all equipment and materials shall be installed with the acceptance of the Engineer and in accordance with the recommendations of the manufacturer. This includes the performance of such tests as the manufacturer recommends.

D. All labor for installation of mechanical systems shall be performed by experienced, skilled tradesmen under the supervision of a licensed journeyman foreman. All work shall be of a quality consistent with good trade practice and shall be installed in a neat, workmanlike manner. The Engineer reserves the right to reject any work which, in his opinion, has been installed in a substandard, dangerous, or unserviceable manner. The Contractor shall replace said work in a satisfactory manner at no extra cost to the Owner.

1.16 PROTECTION OF MATERIALS AND EQUIPMENT

A. Work under each Section shall include protecting the work and material of all other Sections from damage by work or workmen and shall include making good all damage thus caused.

B. The Contractor shall be responsible for work and equipment until the facility has been accepted by the Owner. Protect work against theft, injury, or damage and carefully store material and equipment received on site which is not immediately installed. Close open ends of work with temporary covers or plugs during construction to prevent entry of foreign material.

C. Work under each Section includes receiving, unloading, uncrating, storing, protecting, setting in place, and completely connecting equipment supplied under each Section. Work under each Section shall also include exercising special care in handling and protecting equipment and fixtures and shall include the cost of replacing any of the equipment and fixtures which are missing or damaged.

D. Equipment and material stored on the job site shall be protected from the weather, vehicles, dirt and/or damage by workmen or machinery. Ensure that all electrical or absorbent equipment or material is protected from moisture during storage.

1.17 BASES AND SUPPORTS

A. Unless otherwise specifically noted, the Contractor shall furnish all necessary supports, rails, framing, bases, and piers required for all equipment furnished under this Division.

B. Unless otherwise indicated in individual trade Sections, pumps, fans, air handlers, boilers, chillers, tanks, compressors, and other rotating machinery shall be mounted on a minimum of 4-inch-high concrete pads which shall be furnished and installed per Division 03. All pads shall be extended not less than 4 inches beyond machine base in all directions and sufficient for seismic anchoring with top edge chamfered. Shop drawings of all foundations and pads shall be submitted to the Engineer for review before they are constructed. The Mechanical Contractor shall field coordinate all required dimensional and necessary loading information.

C. Construction of foundations, supports, pads, bases, and piers where mounted on the floor shall be of the same finish quality as the adjacent and surrounding flooring material.

D. Unless otherwise shown, all equipment shall be securely attached to the building structure in an acceptable manner. Attachments shall be of a strong and durable nature; any attachments that are insufficient, in the opinion of the Engineer, shall be replaced as directed without extra cost to the Owner.

E. All equipment supports shall be designed and constructed such that the equipment will be capable of resisting both vertical and horizontal movement. The equipment shall be positively anchored to the bases or supports to resist vertical movement. The equipment and its supports shall be provided with suitable restraints to resist horizontal movement from any direction as dictated by applicable seismic Codes.

1.18 SLEEVES, INSERTS, AND ANCHOR BOLTS

A. The Contractor shall provide, set in place, and be held responsible for the location of all sleeves, inserts, and anchor bolts required for the work. In the event that failure to do so requires cutting and patching of finished work, it shall be done at the Contractor's expense.

1. It is the responsibility of the Contractor to furnish cast-in-place sleeves, inserts, and anchors in sufficient time to be installed during initial concrete pours. Where job schedules make this impossible, coordinate and obtain acceptance from the Structural Engineer for alternate installation methods.

B. All pipes and conduits passing through floors, walls or partitions shall be provided with sleeves having an inside diameter 1-inch larger than the outside diameter of the pipe, conduit, or insulation enclosing the pipe.

C. Penetrations through fire-rated walls, ceilings, and all floors (except slab on grade) in which piping or ducts pass shall be filled solidly with acceptable firestopping material.

D. When ducts, piping, or conduit penetrate the floor of a mechanical room located above an occupied space, such penetrations shall be made completely watertight, such that a liquid leak shall not pass through the penetration.

1.19 CUTTING AND PATCHING

A. All cutting and patching shall be done per Division 01 requirements. The Contractor shall furnish sketches showing the location and sizes of all openings, chases, etc., required for the installation of work.

B. Work under this Division shall include furnishing, locating, and setting inserts and/or sleeves required before the floors and walls are built or be responsible for cutting, drilling, or chopping where sleeves and inserts were not installed or correctly located. The Contractor shall do all drilling required for the installation of hangers.

C. Exercise extreme caution when core drilling or punching openings in concrete floor slabs in order to avoid cutting or damaging structural members. No structural members or structural slabs/floors shall be cut without the written acceptance of the Structural Engineer and all such cutting shall be done in a manner directed by him.

1.20 SCAFFOLDING, RIGGING, HOISTING

A. The Contractor shall furnish all scaffolding, rigging, hoisting, and services necessary for erection and delivery into the premises any equipment and apparatus furnished under this Division. Remove same from premises when no longer required.

1.21 EXCAVATION AND BACKFILLING

A. Excavation and backfilling shall be done per Division 31 of the Specifications.

B. It is the responsibility of the Contractor to coordinate sizes, depths, fill, and bedding requirements and any other excavation work required under this Division.

1.22 WATERPROOFING

A. Where any work pierces waterproofing, including waterproof concrete and floors in wet areas, the method of installation shall be reviewed by the Engineer before work is done. The Contractor shall furnish all necessary sleeves, caulking, and flashing required to make openings absolutely watertight.

1.23 ACCESSIBILITY AND ACCESS PANELS

A. The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate thickness of partitions, and the adequate clearance in double partitions and hung ceilings for the proper installation of the work.

B. Locate all equipment which must be serviced, operated, or maintained in fully accessible positions. Equipment shall include, but not be limited to motors, controllers, coil, valves, switchgear, drain points, etc. Access doors shall be furnished if required for better accessibility. Minor deviations from the Drawings may be made to allow better accessibility, but changes of magnitude or which involve extra cost shall not be made without the acceptance of the Engineer.

C. Access doors in walls, ceilings, floors, etc., shall be field coordinated. It is the responsibility of the Contractor to coordinate and provide information regarding the sizes and quantities of

access doors required for his work. The Contractor shall arrange his work in such a manner as to minimize the quantity of access doors required, such as grouping shutoff valves in the same area. Where possible, locate valves in already accessible areas, such as lay-in ceilings, etc.

D. On a clean set of prints, the Contractor shall mark in red pencil the location of each required access door, including its size and fire rating (if any), and shall submit the print to the Architect for review before access doors are purchased or installed.

E. Upon completion of the Project, the Contractor shall physically demonstrate that all equipment and devices installed have been located and/or provided with adequate access panels for repair, maintenance and/or operation. Any equipment not so furnished shall be relocated or provided with additional access panels by the installing Contractor at no additional cost to the Owner.

F. Permanent ladders for access to equipment when shown on Plans shall be furnished and installed. Coordinate exact requirements in field.

1.24 TEMPORARY OPENINGS

A. The Contractor shall ascertain from an examination of the Drawings whether any special temporary openings in the building will be required for the admission of apparatus provided under this Division and shall coordinate the requirements accordingly. In the event of failure of the Contractor to give sufficient notice in time to arrange for these openings during construction, the Contractor shall assume all costs of providing such openings thereafter.

1.25 SHUTDOWNS

A. When installation of a new system requires the temporary shutdown of an existing operating system, the connection of the new system shall be performed at such time as designated by the Owner's representative.

B. The Engineer and the Owner shall be notified of the estimated duration of the shutdown period at least ten (10) days in advance of the date the work is to be performed.

C. Work shall be arranged for continuous performance whenever possible. The Contractor shall provide all necessary labor, including overtime if required, to assure that existing operating services will be shut down only during the time actually required to make necessary connections.

1.26 TAGS AND CHARTS

A. Each valve and piece of apparatus under this Division shall be provided with suitable brass or laminated plastic tags and ceiling tag securely fastened with brass chains, screws, or rivets. Equipment shall be numbered with laminated plastic tags or neatly stenciled letters 2 inches high using designations in equipment schedules and/or shall conform to a directory indicating number, location, and use of each item. Directories shall be prepared under each Section and shall be glass framed.

1. Directory shall indicate valve tag number and the unit number, floor/area branch line, main line, service, or other pertinent data to quickly and easily identify the valve’s purpose.

1.27 ESCUTCHEONS

A. The Contractor shall provide escutcheons on pipes wherever they pass through floors, ceilings, walls, or partitions in finished visible locations. See Section 078413 “Penetration Firestopping” for further requirements.

1.28 PAINTING

A. All finish painting in completed areas shall be performed per Division 09 of the Specifications.

B. All materials shipped to the job site under this Division, such as grilles, registers, and/or radiation covers, shall have standard manufacturer's finish, unless otherwise specified.

C. The Contractor shall paint the interior of all ducts wherever the interior of the duct can be seen through a register or louver. Paint shall be flat black, rust preventative type.

D. The Contractor shall paint conduits, pipe, and equipment wherever it can be seen through a register or louver. Paint shall not cover-up labels and other identifying items. Paint shall be flat black, rust preventative type.

E. All uninsulated outdoor piping and fittings shall be properly primed with zinc-rich primer and finished with a minimum of two (2) coats of high-grade exterior enamel.

1.29 PIPE EXPANSION

A. All pipe connections shall be installed to allow for freedom of movement of the piping during expansion and contraction without springing. Provide engineered design, layout, details, and fabrication, submitted with registered professional engineer sign and seal, of swing joints, expansion loops, and expansion joints with proper anchors and guides. Pay particular attention to plastic piping with high coefficients of expansion.

1. Consideration of required seismic lateral restraints shall be given when anchoring piping and making provision for expansion.

1.30 ELECTRICAL CONNECTIONS

A. Unless otherwise specified, all wiring shall be furnished and installed per Division 26 Specifications.

B. The Contractor furnishing equipment shall furnish the motor controller required for the equipment. Provide properly sized overload heaters and all required accessories with all motor controllers. See Division 26 for motor controller requirements.

C. All power wiring shall be furnished and installed per Division 26 complete from power source to motor or equipment junction box including power wiring through the motor controller and proper means of disconnect per NEC and Division 26. The Division 26 Contractor shall provide all disconnects, unless noted otherwise.

1.31 QUIET OPERATION

A. Equipment and material used in the various systems described herein shall not produce a sound level greater than 55 decibels in the area served. If noise level is deemed objectionable by the Owner/Engineer, the Contractor shall test and record sound levels in the presence of the Owner/Engineer. The sound level shall be observed on the "A" weighting network of a sound level or sound survey meter. The ASHRAE "Guide and Data Book" provides a means to

determine sound level of mechanical equipment when the total of background plus equipment sound levels exceeds the minimum acceptable equipment sound level.

B. If objectionable noises or vibrations of any magnitude are produced and transmitted to occupied portions of the building by apparatus, piping, ducts, or other parts of the mechanical work, the Contractor shall make such changes or additions as necessary without extra cost to the Owner.

1.32 MAINTENANCE

A. The Contractor shall provide the necessary skilled labor to assure the proper operation and to provide all required current and preventative maintenance for all equipment and controls provided under this Division until final acceptance of the building by the Owner. The Contractor shall not assume acceptance of the building by the Owner until he receives written notification.

B. The Contractor shall receive calls for any and all problems experienced in the operation of the equipment provided under this Division and he shall take steps to immediately correct any deficiencies that may exist.

C. The Contractor shall provide a check list and shall put a copy of it in the boiler or main mechanical room. The check list shall itemize each piece of equipment furnished under his Section.

1. The Contractor shall certify on this check list that he has examined each piece of equipment and that, in his opinion, it is operating as intended by the manufacturer, it has been properly lubricated, and that all necessary current and preventative maintenance has been performed as recommended by the manufacturer and by good and accepted practice.

D. Where normal preventative maintenance for any piece of equipment requires special tools, the Contractor shall furnish the appropriate tools for that piece of equipment (i.e., special filter removal hooks, valve wrenches, etc.).

1.33 LUBRICATION

A. All equipment installed under this Contract having moving parts and requiring lubrication shall be properly lubricated according to manufacturer's recommendations prior to testing and operation. Any such equipment discovered to have been operated before lubrication by the Contractor is subject to rejection and replacement at no additional cost to the Owner. Units furnished with sealed bearings are exempted.

B. The Contractor shall furnish and install, as appropriate on all equipment requiring lubrication, Zerk pressure gun grease fittings or sight gravity-feed oilers equipped with shutoff and needle valve adjustment. Units furnished with sealed bearings and lifetime lubrication are exempted. All fittings and oilers are to be fully accessible for lubrication with equipment which does not require special adapters. Where fittings would be otherwise inaccessible, furnish and install extended grease lines.

1.34 CLEANING

A. The Contractor shall be responsible for keeping the jobsite clean, safe, and neat throughout the duration of construction. The Contractor shall clean up his own debris daily and shall coordinate removal of rubbish and debris with the General Contractor/Construction Manager.

1. No debris, construction materials, cigarette butts, coffee cups, etc., shall be left above suspended ceilings.

B. The Contractor shall thoroughly clean and flush all piping and equipment of all foreign substances, oils, burrs, solder, flux, etc., inside and out before being placed in operation.

C. If any part of a system should be stopped or damaged by any foreign matter after being placed in operation, the system shall be disconnected, cleaned, and reconnected wherever necessary to locate and/or remove obstructions. Any work damaged in the course of removing obstructions shall be repaired or replaced when the system is reconnected at no additional cost to the Owner.

D. During the course of construction, all ducts and pipes shall be capped in an acceptable manner to insure adequate protection against the entrance of foreign matter.

E. Upon completion of all work under the Contract, the Contractor shall remove from the premises all rubbish, debris, and excess materials left over from his work. Any oil or grease stains on floor areas caused by the Contractor shall be removed and floor areas left clean.

1.35 OPERATING INSTRUCTIONS

A. Refer to Section 017823 “Operation and Maintenance Data”.

B. Upon completion of all work and tests, the Contractor shall furnish the necessary skilled labor and helpers for operating his system and equipment for a period specified under each applicable Section of this Division. During this period, he shall fully instruct the Owner or the Owner's representative in the operation, adjustment, and maintenance of all equipment furnished. The Contractor shall give at least 72 hours’ notice to the Owner and the Engineer in advance of this period.

C. The Contractor, in the above-mentioned instructions, shall include the maintenance schedule for the principal items of equipment furnished under this Division.

D. The appropriate Contractor shall physically demonstrate procedures for all routine maintenance of all equipment furnished under each respective Section to assure accessibility to all devices.

E. An authorized manufacturer's representative shall attest in writing that the equipment has been properly installed prior to startup of any major equipment. The following equipment will require this inspection: pumps; air conditioning equipment, controls, air handling equipment, boilers. These letters will be bound into the operating and maintenance books.

F. Refer to individual trade Sections for any other particular requirements related to operating instructions.

1.36 ADJUSTING AND TESTING

A. After all the equipment and accessories to be furnished are in place, they shall be put in final adjustment and subjected to such operating tests so as to assure the Engineer that they are in proper adjustment and in satisfactory, permanent operating condition.

B. Where requested by the Engineer, a factory-trained service engineering representative shall inspect the installation and assist in the initial startup and adjustment to the equipment. The period of these services shall be for such time as necessary to secure proper installation and adjustments. After the equipment is placed in permanent operation, the service engineering representative shall supervise the initial operation of the equipment and instruct the personnel responsible for operation and maintenance of the equipment. The service engineering representative shall notify the Contractor in writing that the equipment was installed according to manufacturer's recommendations and is operating as intended by the manufacturer.

1.37 GUARANTEES

A. The Contractor shall guarantee all equipment, material, and workmanship under these Specifications and the Contract for a period of one (1) year from the date of final acceptance by Owner, unless otherwise noted.

B. During this guarantee period, all defects developing through faulty equipment, materials, or workmanship shall be corrected or replaced immediately by the Contractor without expense to the Owner. Such repairs or replacements shall be made to the Engineer's satisfaction.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 220100

SECTION 220513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

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 general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 100 deg F and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one (1) of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multi-speed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Used)

END OF SECTION 220513

SECTION 220516 - EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

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. Flexible-hose packless expansion joints.
2. Metal-bellows packless expansion joints.
3. Rubber packless expansion joints.
4. Grooved-joint expansion joints.
5. Alignment guides and anchors.
6. Pipe loops and swing connections.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For expansion joints to include in maintenance manuals.

1.6 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb two hundred percent (200%) of maximum axial movement between anchors.

2.2 PACKLESS EXPANSION JOINTS

A. Flexible-Hose Packless Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Flex Pression Ltd.
    b. Flex-Hose Co., Inc.
    c. Flexicraft Industries
    d. Mason Industries, Inc.
    e. Metraflex Company (The)
    f. Unisource Manufacturing, Inc.

2. Description: Manufactured assembly with inlet and outlet elbow fittings and two (2) flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
4. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with solder-joint end connections.

    a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.

5. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4: Copper-alloy fittings with threaded end connections.

    a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.

6. Expansion Joints for Steel Piping NPS 2 and Smaller: Carbon-steel fittings with threaded end connections.

    a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings.

7. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6: Carbon-steel fittings with flanged end connections.

    a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.

B. Metal-Bellows Packless Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Adsco Manufacturing LLC
    b. American BOA, Inc.
    c. Badger Industries, Inc.
    d. Expansion Joint Systems, Inc.
    e. Flex Pression Ltd.
    f. Flex-Hose Co., Inc.
    g. Flexicraft Industries
    h. Flex-Weld, Inc.
    i. Flo Fab Inc.
    j. Hyspan Precision Products, Inc.
    k. Mason Industries, Inc.
    l. Metraflex Company (The)
    m. Proco Products, Inc.
    n. Senior Flexonics Pathway
    o. Tozen Corporation
    p. U.S. Bellows, Inc.
    q. Unaflex
    r. Unisource Manufacturing, Inc.
    s. Universal Metal Hose
    t. WahlcoMetroflex

2. Standards: ASTM F 1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
3. Type: Circular, corrugated bellows with external tie rods.
4. Minimum Pressure Rating: 150 psig, unless otherwise indicated.
5. Configuration: Single joint class(es), unless otherwise indicated.
6. Expansion Joints for Copper Tubing: Single- or multi- ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.

    a. End Connections for Copper Tubing NPS 2 and Smaller: threaded.
    b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: threaded.
    c. End Connections for Copper Tubing NPS 5 and Larger: Flanged.

7. Expansion Joints for Steel Piping: Single- or multi- ply stainless-steel bellows, steel pipe ends, and carbon-steel shroud.

    a. End Connections for Steel Pipe NPS 2 and Smaller: Threaded.
    b. End Connections for Steel Pipe NPS 2-1/2 and Larger: Flanged.

C. Rubber Packless Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Amber/Booth Company, Inc.; a VMC Group Company
    b. Flex-Hose Co., Inc.
    c. Flexicraft Industries
    d. Flex-Weld, Inc.
    e. Garlock Sealing Technologies
    f. General Rubber Corporation
    g. Mason Industries, Inc.
    h. Metraflex Company (The)
    i. Proco Products, Inc.

j. Red Valve Company, Inc.
k. Tozen Corporation
l. Unaflex
m. Unisource Manufacturing, Inc.

2. Standards: ASTM F 1123 and FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
3. Material: Fabric-reinforced rubber complying with FSA-PSJ-703.
4. Arch Type: Single or multiple arches with external control rods.
5. Spherical Type: Single or multiple spheres with external control rods.
6. Minimum Pressure Rating for NPS 1-1/2 to NPS 4: 150 psig at 220 deg F.
7. Minimum Pressure Rating for NPS 5 and NPS 6: 140 psig at 200 deg F.
8. Minimum Pressure Rating for NPS 8 to NPS 12: 140 psig at 180 deg F.
9. Material for Fluids Containing Acids, Alkalis, or Chemicals: Ethylene-propylene-diene terpolymer rubber.
10. Material for Fluids Containing Gas, Hydrocarbons, or Oil: Buna-N.
11. Material for Water: Ethylene-propylene-diene terpolymer rubber.
12. End Connections: Full-faced, integral steel flanges with steel retaining rings.

2.3 GROOVED-JOINT EXPANSION JOINTS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Anvil International
2. Shurjoint Piping Products
3. Victaulic Company

B. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.

C. Standard: AWWA C606, for grooved joints.

D. Nipples: Galvanized, ASTM A 53, Schedule 40, Type E or S, steel pipe with grooved ends.

2.4 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Adsco Manufacturing LLC
b. Advanced Thermal Systems, Inc.
c. Flex-Hose Co., Inc.
d. Flexicraft Industries
e. Flex-Weld, Inc.
f. Hyspan Precision Products, Inc.
g. Mason Industries, Inc.
h. Metraflex Company (The)
i. Senior Flexonics Pathway
j. U.S. Bellows, Inc.
k. Unisource Manufacturing, Inc.

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A 36.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened Portland cement concrete, with tension and shear capacities appropriate for application.

    a. Stud: Threaded, zinc-coated carbon steel.
    b. Expansion Plug: Zinc-coated steel.
    c. Washer and Nut: Zinc-coated steel.

5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened Portland cement concrete, with tension and shear capacities appropriate for application.

    a. Bonding Material: ASTM C 881, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
    b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
    c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION JOINT INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

B. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

C. Install rubber packless expansion joints according to FSA-PSJ-703.

D. Install grooved-joint expansion joints to grooved-end steel piping.

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Connect risers and branch connections to mains with at least five (5) pipe fittings, including tee in main.

C. Connect risers and branch connections to terminal units with at least four (4) pipe fittings, including tee in riser.

D. Connect mains and branch connections to terminal units with at least four (4) pipe fittings, including tee in main.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install two (2) guides on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four (4) pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

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

E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 220516

SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

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. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

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

B. Galvanized-Steel Wall Pipes: ASTM A 53, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Jay R. Smith Mfg. Co.
2. Zurn Industries, LLC

B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. GPT; an EnPro Industries company
4. Metraflex Company (The)
5. Proco Products, Inc.

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

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Plastic or stainless-steel.
3. Connecting Bolts and Nuts: Stainless-steel of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. GPT; an EnPro Industries company
4. Metraflex Company (The)
5. Proco Products, Inc.

B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

A. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

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

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

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

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

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

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

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

2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide ¼-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide ¼-inch annular clear space between sleeve and pipe or pipe insulation.
2. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
3. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
4. Using grout, seal the space around outside of stack-sleeve fittings.

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

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

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

3.4 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:

a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves.
b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves.

2. Exterior Concrete Walls below Grade:

a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves with sleeve-seal system.

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

b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves with sleeve-seal system.

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

3. Concrete Slabs-on-Grade:

a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves with sleeve-seal system.

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

b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves with sleeve-seal system.

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

END OF SECTION 220517

SECTION 220518 - ESCUTCHEONS FOR PLUMBING PIPING

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. Escutcheons.
2. Floor plates.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated and rough-brass finish and setscrew fastener.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

D. Split-Casting Brass Type: With polished, chrome-plated and rough-brass finish and with concealed hinge and setscrew.

E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.2 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
c. Insulated Piping: One-piece, stamped-steel type.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
f. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type.
g. Bare Piping in Equipment Rooms: One-piece, stamped-steel type.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 220518

SECTION 220519 - METERS AND GAGES FOR PLUMBING PIPING

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. Bimetallic-actuated thermometers.
2. Filled-system thermometers.
3. Liquid-in-glass thermometers.
4. Thermowells.
5. Dial-type pressure gages.
6. Gage attachments.
7. Test plugs.
8. Test-plug kits.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gage.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Ashcroft Inc.
2. Ernst Flow Industries
3. Marsh Bellofram
4. Miljoco Corporation
5. Nanmac Corporation
6. Noshok
7. Palmer Wahl Instrumentation Group
8. REOTEMP Instrument Corporation
9. Tel-Tru Manufacturing Company
10. Trerice, H. O. Co.

11. Watts; a Watts Water Technologies company
12. Weiss Instruments, Inc.
13. Weksler Glass Thermometer Corp.
14. WIKA Instrument Corporation
15. Winters Instruments - U.S.

B. Standard: ASME B40.200.

C. Case: Liquid-filled and sealed type(s); stainless-steel with 3-inch nominal diameter.

D. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F.

E. Connector Type(s): Union joint, adjustable angle and rigid, bottom, with unified-inch screw threads.

F. Connector Size: ½-inch, with ASME B1.1 screw threads.

G. Stem: 0.25- or 0.375-inch in diameter; stainless-steel.

H. Window: Plain glass.

I. Ring: Stainless-steel.

J. Element: Bimetal coil.

K. Pointer: Dark-colored metal.

L. Accuracy: Plus or minus one percent (+/-1%) of scale range.

2.2 FILLED-SYSTEM THERMOMETERS

A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Ashcroft Inc.
    b. Marsh Bellofram
    c. Miljoco Corporation
    d. Palmer Wahl Instrumentation Group
    e. REOTEMP Instrument Corporation
    f. Trerice, H. O. Co.
    g. Weiss Instruments, Inc.

2. Standard: ASME B40.200.
3. Case: Sealed type, cast aluminum or drawn steel; 4½-inch nominal diameter.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: Stainless-steel.
10. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device rigid, bottom; with ASME B1.1 screw threads.

11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

    a. Design for Thermowell Installation: Bare stem.

12. Accuracy: Plus or minus one percent (+/-1%) of scale range.

2.3 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Trerice, H. O. Co.

2. Standard: ASME B40.200.
3. Case: Cast aluminum; 6-inch nominal size.
4. Case Form: Back angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass or plastic.
8. Stem: Aluminum or brass and of length to suit installation.

    a. Design for Thermowell Installation: Bare stem.

9. Connector: ¾-inch, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus one percent (+/-1%) of scale range or one scale division, to a maximum of one and one-half percent (1.5%) of scale range.

B. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Flo Fab Inc.
    b. Miljoco Corporation
    c. Palmer Wahl Instrumentation Group
    d. Tel-Tru Manufacturing Company
    e. Trerice, H. O. Co.
    f. Weiss Instruments, Inc.
    g. Weksler Glass Thermometer Corp.
    h. Winters Instruments - U.S.

2. Standard: ASME B40.200.
3. Case: Cast aluminum; 7-inch nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass.
8. Stem: Aluminum and of length to suit installation.

a. Design for Thermowell Installation: Bare stem.

9. Connector: 1¼ inches, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus one percent (+/-1%) of scale range or one scale division, to a maximum of one and one-half percent (1.5%) of scale range.

2.4 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: ½-, ¾-, and 1-inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

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

2.5 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Ametek U.S. Gauge
b. Ashcroft Inc.
c. Ernst Flow Industries
d. Flo Fab Inc.
e. Marsh Bellofram
f. Miljoco Corporation
g. Noshok
h. Palmer Wahl Instrumentation Group
i. REOTEMP Instrument Corporation
j. Tel-Tru Manufacturing Company
k. Trerice, H. O. Co.
l. Watts; a Watts Water Technologies company
m. Weiss Instruments, Inc.
n. Weksler Glass Thermometer Corp.
o. WIKA Instrument Corporation
p. Winters Instruments - U.S.

2. Standard: ASME B40.100.
3. Case: Liquid-filled Sealed type(s); cast aluminum or drawn steel; 4½-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.

6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Stainless-steel.
11. Accuracy: Grade A, plus or minus one percent (+/-1%) of middle half of scale range.

2.6 GAGE ATTACHMENTS

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

B. Valves: Brass ball, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.7 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Flow Design, Inc.
2. Miljoco Corporation
3. Nexus Valve, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Watts; a Watts Water Technologies company
8. Weiss Instruments, Inc.
9. Weksler Glass Thermometer Corp.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless-steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

F. Core Inserts: EPDM self-sealing rubber.

2.8 TEST-PLUG KITS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Flow Design, Inc.
2. Miljoco Corporation
3. Nexus Valve, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Watts; a Watts Water Technologies company
8. Weiss Instruments, Inc.

B. Furnish one (1) test-plug kit containing thermometer(s), one (1) pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

C. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch-diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F.

D. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch-diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F.

E. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch-diameter dial and probe. Dial range shall be at least 0 to 200 psig.

F. Carrying Case: Metal or plastic, with formed instrument padding.

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

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

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

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

H. Install test plugs in piping tees.

I. Install thermometers in the following locations:

1. Inlet and outlet of each water heater.

J. Install pressure gages in the following locations:

1. Building water service entrance into building.
2. Inlet and outlet of each pressure-reducing valve.
3. Suction and discharge of each domestic water pump.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

3.3 ADJUSTING

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

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each domestic water heater shall be the following:

1. Liquid-filled Sealed, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.
3. Metal case, compact industrial-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with EPDM self-sealing rubber inserts.

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

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F.

B. Scale Range for Domestic Hot-Water Piping: 0 to 250 deg F.

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each water service into building shall be the following:

1. Liquid-filled, sealed open-front, pressure-relief or solid-front, pressure-relief, direct - mounted, metal case.
2. Sealed, direct-mounted, plastic case.
3. Test plug with EPDM self-sealing rubber inserts.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Water Service Piping: 0 to 200 psi.

B. Scale Range for Domestic Water Piping: 0 to 200 psi.

END OF SECTION 220519

SECTION 220523.12 - BALL VALVES FOR PLUMBING PIPING

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. Bronze ball valves.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61 Annex G and NSF 372.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, and soldered ends.
3. Set ball valves open to minimize exposure of functional surfaces.

B. Use the following precautions during storage:

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

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.

2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for flanges on steel valves.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.18 for solder-joint connections.
6. ASME B31.9 for building services piping valves.

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

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

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

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

G. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 4 and larger.
2. Handlever: For quarter-turn valves smaller than NPS 4.

H. Valves in Insulated Piping:

1. Include 2-inch stem extensions.
2. Extended operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

2.2 BRONZE BALL VALVES

A. Bronze Ball Valves, Two-Piece with Full Port and Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Apollo Valves; Conbraco Industries, Inc.
b. Crane; Crane Energy Flow Solutions
c. Hammond Valve
d. Lance Valves
e. Milwaukee Valve Company
f. NIBCO INC.
g. Watts; a Watts Water Technologies company

2. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 600 psig.
c. Body Design: Two-piece.
d. Body Material: Bronze.
e. Ends: Threaded or soldered.
f. Seats: PTFE.
g. Stem: Stainless-steel.
h. Ball: Stainless-steel, vented.
i. Port: Full.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

3.2 VALVE INSTALLATION

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

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

C. Install valves in horizontal piping with stem at or above center of pipe.

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

E. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.

3.4 VALVE SCHEDULE (150 PSIG OR LESS)

A. Pipe NPS 2 and Smaller:

1. Refer to Valve Schedule on Drawings.

END OF SECTION 220523.12

SECTION 220523.14 - CHECK VALVES FOR PLUMBING PIPING

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. Bronze swing check valves.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene-diene terpolymer rubber.

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

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61 Annex G and NSF 372.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set check valves in either closed or open position.

B. Use the following precautions during storage:

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

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for solder joint.
5. ASME B31.9 for building services piping valves.

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

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

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

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

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

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

2.2 BRONZE SWING CHECK VALVES

A. Bronze Swing Check Valves with Bronze Disc, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. American Valve, Inc.
b. Apollo Valves; Conbraco Industries, Inc.
c. Crane; Crane Energy Flow Solutions
d. Hammond Valve
e. Jenkins Valves; Crane Energy Flow Solutions
f. KITZ Corporation
g. Macomb Groups (The)
h. Milwaukee Valve Company
i. NIBCO INC.
j. Powell Valves
k. Red-White Valve Corporation
l. Stockham; Crane Energy Flow Solutions
m. Watts; a Watts Water Technologies company

2. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded or soldered. See valve schedule articles.
f. Disc: Bronze.

B. Bronze Swing Check Valves with Nonmetallic Disc, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Apollo Valves; Conbraco Industries, Inc.
    b. Crane; Crane Energy Flow Solutions
    c. Hammond Valve
    d. Jenkins Valves; Crane Energy Flow Solutions
    e. KITZ Corporation
    f. Milwaukee Valve Company
    g. NIBCO INC.
    h. Red-White Valve Corporation
    i. Stockham; Crane Energy Flow Solutions
    j. Watts; a Watts Water Technologies company

2. Description:

    a. Standard: MSS SP-80, Type 4.
    b. CWP Rating: 200 psig.
    c. Body Design: Horizontal flow.
    d. Body Material: ASTM B 62, bronze.
    e. Ends: Threaded or soldered. See valve schedule articles.
    f. Disc: PTFE.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

3.2 VALVE INSTALLATION

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

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

C. Install valves in horizontal piping with stem at or above center of pipe.

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

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

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
3. Lift Check Valves: With stem upright and plumb.

F. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Pump-Discharge Check Valves:

a. NPS 2 and Smaller: Bronze swing check valves with bronze or nonmetallic disc.

B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

C. End Connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded or soldered.

3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze swing check valves with bronze disc, Class 125, with threaded end connections.

END OF SECTION 220523.14

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

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. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Fiberglass pipe hangers.
4. Metal framing systems.
5. Fiberglass strut systems.
6. Thermal-hanger shield inserts.
7. Fastener systems.
8. Pipe stands.
9. Pipe positioning systems.
10. Equipment supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

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

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

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.5 ACTION SUBMITTALS

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

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers.

2. Metal framing systems.
3. Fiberglass strut systems.
4. Pipe stands.
5. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

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

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless-steel.

C. Copper Pipe Hangers:

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

2.2 TRAPEZE PIPE HANGERS

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

2.3 FIBERGLASS PIPE HANGERS

A. Clevis-Type, Fiberglass Pipe Hangers:

1. Description: Similar to MSS SP-58, Type 1, steel pipe hanger except hanger is made of fiberglass or fiberglass-reinforced resin.
2. Hanger Rods: Continuous-thread rod, washer, and nuts made of stainless-steel.

B. Strap-Type, Fiberglass Pipe Hangers:

1. Description: Similar to MSS SP-58, Type 9 or Type 10, steel pipe hanger except hanger is made of fiberglass-reinforced resin.
2. Hanger Rod and Fittings: Continuous-thread rod, washer, and nuts made of stainless-steel.

2.4 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Allied Tube & Conduit; a part of Atkore International
b. B-line, an Eaton business
c. Flex-Strut Inc.
d. Thomas & Betts Corporation; A Member of the ABB Group
e. Unistrut; Part of Atkore International
f. Wesanco, Inc.

2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless-steel.
7. Metallic Coating: Hot-dipped galvanized.
8. Paint Coating: Epoxy.
9. Plastic Coating: Epoxy.

2.5 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Carpenter & Paterson, Inc.
2. Clement Support Services
3. ERICO International Corporation
4. National Pipe Hanger Corporation

5. PHS Industries, Inc.
6. Pipe Shields Inc.
7. Piping Technology & Products, Inc.
8. Rilco Manufacturing Co., Inc.
9. Value Engineered Products, Inc.

B. Insulation-Insert Material for Cold Piping: ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.

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

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

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

2.6 FASTENER SYSTEMS

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

2.7 PIPE STANDS

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

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

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

D. High-Type, Single-Pipe Stand:

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

E. High-Type, Multiple-Pipe Stand:

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

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

2.8 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, positioning system of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.9 EQUIPMENT SUPPORTS

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

2.10 MISCELLANEOUS MATERIALS

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

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

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

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

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

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

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

C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

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

E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.

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

G. Fastener System Installation:

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

H. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb.

I. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

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

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

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

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

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

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

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

Q. Insulated Piping:

1. Attach clamps and spacers to piping.

   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

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

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

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

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

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

    a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048-inch-thick.
    b. NPS 4: 12 inches long and 0.06-inch-thick.
    c. NPS 5 and NPS 6: 18 inches long and 0.06-inch-thick.
    d. NPS 8 to NPS 14: 24 inches long and 0.075-inch-thick.
    e. NPS 16 to NPS 24: 24 inches long and 0.105-inch-thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

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

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

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

3.3 METAL FABRICATIONS

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

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

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

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

3.4 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1½ inches.

3.5 PAINTING

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

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

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

3.6 HANGER AND SUPPORT SCHEDULE

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

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

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

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

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

F. Use stainless-steel pipe hangers and fiberglass pipe hangers and fiberglass strut systems and stainless-steel attachments for hostile environment applications.

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

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

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

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

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
3. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
4. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
5. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated, stationary pipes NPS 3/4 to NPS 8.
6. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
7. Adjustable Band Hangers (MSS Type 9): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.

8. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
9. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 8.
10. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 3.
11. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
12. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
13. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
14. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two (2) rods if longitudinal movement caused by expansion and contraction might occur.
15. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
16. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
17. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
18. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

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

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

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

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

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

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

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

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

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

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

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1¼ inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to twenty-five percent (25%) to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to twenty-five percent (25%) to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to twenty-five percent (25%) to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

a. Horizontal (MSS Type 54): Mounted horizontally.
b. Vertical (MSS Type 55): Mounted vertically.
c. Trapeze (MSS Type 56): Two (2) vertical-type supports and one (1) trapeze member.

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

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

R. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

S. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 220529

SECTION 220533 - HEAT TRACING FOR PLUMBING PIPING

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 plumbing piping heat tracing for freeze prevention, domestic hot-water-temperature maintenance, and snow and ice melting on roofs and in gutters and downspouts with the following electric heating cables:

1. Plastic insulated, series resistance.
2. Self-regulating, parallel resistance.
3. Constant wattage.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
2. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.

B. Shop Drawings: For electric heating cable.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Two (2) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Chromalox, Inc.
2. Raychem; Tyco Thermal Controls
3. Thermon Americas Inc.

B. Comply with IEEE 515.1.

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

D. Electrical Insulating Jacket: Flame-retardant polyolefin.

E. Cable Cover: Tinned-copper braid and polyolefin outer jacket.

F. Maximum Operating Temperature (Power On): 150 deg F.

G. Maximum Exposure Temperature (Power Off): 170 deg F (adj.).

H. 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.

I. Capacities and Characteristics:

1. Refer to Schedules on Drawings.
2. Number of Parallel Cables: Two (2).

2.2 CONTROLS

A. Pipe-Mounted Thermostats for Freeze Protection:

1. Remote bulb unit with adjustable temperature range from 30 to 50 deg F.
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.
3. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.
4. Corrosion-resistant, waterproof control enclosure.

2.3 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Labels: Refer to Section 220553 "Identification for Plumbing Piping and Equipment."

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.

1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: ¾-inch minimum.
2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1½ inches minimum.

PART 3 - EXECUTION

3.1 EXAMINATION

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

1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.

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

3.2 INSTALLATION

A. Install electric heating cable across expansion, construction, and control joints according to manufacturer's written instructions; use cable-protection conduit and slack cable to allow movement without damage to cable.

B. Electric Heating-Cable Installation for Freeze Protection for Piping:

1. Install electric heating cables after piping has been tested and before insulation is installed.
2. Install electric heating cables according to IEEE 515.1.
3. Install insulation over piping with electric cables according to Section 220719 "Plumbing Piping Insulation."
4. Install warning tape on piping insulation where piping is equipped with electric heating cables.

C. Electric Heating-Cable Installation for Temperature Maintenance for Domestic Hot Water:

1. Install electric heating cables after piping has been tested and before insulation is installed.
2. Install insulation over piping with electric heating cables according to Section 220719 "Plumbing Piping Insulation."
3. Install warning tape on piping insulation where piping is equipped with electric heating cables.

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

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

C. Cables will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.4 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 220533

SECTION 220548 - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

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. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient supports.
9. Resilient pipe guides.
10. Elastomeric hangers.
11. Spring hangers.
12. Snubbers.
13. Restraint channel bracings.
14. Restraint cables.
15. Seismic-restraint accessories.
16. Mechanical anchor bolts.
17. Adhesive anchor bolts.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.

a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment.

C. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, due to seismic forces required to select vibration isolators, and due to seismic restraints.
3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
4. Seismic-Restraint Details:

a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Ace Mountings Co., Inc.
    b. California Dynamics Corporation
    c. Isolation Technology, Inc.
    d. Kinetics Noise Control, Inc.
    e. Mason Industries, Inc.
    f. Novia; A Division of C&P
    g. Vibration Eliminator Co., Inc.
    h. Vibration Isolation
    i. Vibration Mountings & Controls, Inc.

2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties.
5. Surface Pattern: Ribbed and/or waffle pattern.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: Resilient and/or elastomeric.

    a. Surface Pattern: Ribbed and/or waffle pattern.
    b. Infused nonwoven cotton or synthetic fibers.

2.2 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Ace Mountings Co., Inc.
    b. California Dynamics Corporation

c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Novia; A Division of C&P
g. Vibration Eliminator Co., Inc.
h. Vibration Isolation
i. Vibration Mountings & Controls, Inc.

2. Mounting Plates:

a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.3 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Ace Mountings Co., Inc.
b. California Dynamics Corporation
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Novia; A Division of C&P
g. Vibration Eliminator Co., Inc.
h. Vibration Isolation
i. Vibration Mountings & Controls, Inc.

2. Description: All-directional isolator with seismic restraints containing two (2) separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

a. Housing: Cast-ductile iron or welded steel.
b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Ace Mountings Co., Inc.
b. California Dynamics Corporation
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.

f. Novia; A Division of C&P
g. Vibration Eliminator Co., Inc.
h. Vibration Isolation
i. Vibration Mountings & Controls, Inc.

2. Outside Spring Diameter: Not less than eighty percent (80%) of the compressed height of the spring at rated load.
3. Minimum Additional Travel: Fifty percent (50%) of the required deflection at rated load.
4. Lateral Stiffness: More than eighty percent (80%) of rated vertical stiffness.
5. Overload Capacity: Support two hundred percent (200%) of rated load, fully compressed, without deformation or failure.
6. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig.
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.5 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Ace Mountings Co., Inc.
b. California Dynamics Corporation
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Vibration Eliminator Co., Inc.
g. Vibration Isolation
h. Vibration Mountings & Controls, Inc.

2. Outside Spring Diameter: Not less than eighty percent (80%) of the compressed height of the spring at rated load.
3. Minimum Additional Travel: Fifty percent (50%) of the required deflection at rated load.
4. Lateral Stiffness: More than eighty percent (80%) of rated vertical stiffness.
5. Overload Capacity: Support two hundred percent (200%) of rated load, fully compressed, without deformation or failure.
6. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
b. Top housing with elastomeric pad.

2.6 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Ace Mountings Co., Inc.
b. California Dynamics Corporation
c. Isolation Technology, Inc.

d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Novia; A Division of C&P
g. Vibration Eliminator Co., Inc.
h. Vibration Isolation
i. Vibration Mountings & Controls, Inc.

2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
b. Top plate with elastomeric pad.
c. Internal leveling bolt that acts as blocking during installation.

3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Outside Spring Diameter: Not less than eighty percent (80%) of the compressed height of the spring at rated load.
5. Minimum Additional Travel: Fifty percent (50%) of the required deflection at rated load.
6. Lateral Stiffness: More than eighty percent (80%) of rated vertical stiffness.
7. Overload Capacity: Support two hundred percent (200%) of rated load, fully compressed, without deformation or failure.

2.7 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Ace Mountings Co., Inc.
b. California Dynamics Corporation
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Vibration Eliminator Co., Inc.
g. Vibration Isolation
h. Vibration Mountings & Controls, Inc.

2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.

a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

3. Outside Spring Diameter: Not less than eighty percent (80%) of the compressed height of the spring at rated load.
4. Minimum Additional Travel: Fifty percent (50%) of the required deflection at rated load.
5. Lateral Stiffness: More than eighty percent (80%) of rated vertical stiffness.
6. Overload Capacity: Support two hundred percent (200%) of rated load, fully compressed, without deformation or failure.

2.8 PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two (2) steel tubes separated by a minimum ½-inch-thick neoprene.

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psig on isolation material providing equal isolation in all directions.

2.9 RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two (2) steel tubes or post and sleeve arrangement separated by a minimum ½-inch-thick neoprene.

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.10 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Ace Mountings Co., Inc.
b. California Dynamics Corporation
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Novia; A Division of C&P
g. Vibration Eliminator Co., Inc.
h. Vibration Mountings & Controls, Inc.

2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.11 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Ace Mountings Co., Inc.
b. California Dynamics Corporation
c. Kinetics Noise Control, Inc.
d. Mason Industries, Inc.
e. Novia; A Division of C&P
f. Vibration Eliminator Co., Inc.

g. Vibration Isolation
h. Vibration Mountings & Controls, Inc.

2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than eighty percent (80%) of the compressed height of the spring at rated load.
4. Minimum Additional Travel: Fifty percent (50%) of the required deflection at rated load.
5. Lateral Stiffness: More than eighty percent (80%) of rated vertical stiffness.
6. Overload Capacity: Support two hundred percent (200%) of rated load, fully compressed, without deformation or failure.
7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
9. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.12 SNUBBERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Kinetics Noise Control, Inc.
2. Mason Industries, Inc.
3. Novia; A Division of C&P
4. Vibration Mountings & Controls, Inc.

B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum ¼-inch air gap, and minimum ¼-inch-thick resilient cushion.

2.13 RESTRAINT CHANNEL BRACINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. B-line, an Eaton business
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Unistrut; Part of Atkore International

B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.14 RESTRAINT CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Kinetics Noise Control, Inc.
2. Mason Industries, Inc.
3. Novia; A Division of C&P
4. Vibration & Seismic Technologies, LLC
5. Vibration Mountings & Controls, Inc.

B. Restraint Cables: ASTM A 492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.15 SEISMIC-RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. B-line, an Eaton business
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.
4. Novia; A Division of C&P
5. TOLCO
6. Vibration & Seismic Technologies, LLC

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

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

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.16 MECHANICAL ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. B-line, an Eaton business
2. Hilti, Inc.
3. Kinetics Noise Control, Inc.
4. Mason Industries, Inc.

B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.17 ADHESIVE ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Hilti, Inc.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.

B. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless-steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Division 03.

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Equipment Restraints:

1. Install seismic snubbers on plumbing equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125-inch.
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

D. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

E. Install cables so they do not bend across edges of adjacent equipment or building structure.

F. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

G. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

H. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

I. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

J. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the Structural Engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one

supporting the connections as they approach equipment. Comply with requirements in Section 221116 "Domestic Water Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven (7) days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four (4) of each type and size of installed anchors and fasteners selected by Architect.
5. Test to ninety percent (90%) of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

END OF SECTION 220548

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

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. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Valve tags.
5. Warning tags.

1.3 ACTION SUBMITTALS

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

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

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Brady Corporation
b. Brimar Industries, Inc.
c. Carlton Industries, LP
d. Champion America
e. Craftmark Pipe Markers
f. emedco
g. Kolbi Pipe Marker Co.
h. LEM Products Inc.
i. Marking Services, Inc.
j. Seton Identification Products

2. Material and Thickness: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
3. Letter Color: White.
4. Background Color: Black.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2½-by-¾-inch.
6. Minimum Letter Size: ¼-inch for name of units if viewing distance is less than 24 inches, ½-inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Brady Corporation
    b. Brimar Industries, Inc.
    c. Carlton Industries, LP
    d. Champion America
    e. Craftmark Pipe Markers
    f. emedco
    g. Kolbi Pipe Marker Co.
    h. LEM Products Inc.
    i. Marking Services, Inc.
    j. Seton Identification Products

2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch-thick, and having predrilled holes for attachment hardware.
3. Letter Color: White.
4. Background Color: Black.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2½-by-¾-inch.
7. Minimum Letter Size: ¼-inch for name of units if viewing distance is less than 24 inches, ½-inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
8. Fasteners: Stainless-steel rivets or self-tapping screws.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8½-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Brady Corporation
2. Brimar Industries, Inc.
3. Carlton Industries, LP
4. Champion America
5. Craftmark Pipe Markers
6. emedco
7. LEM Products Inc.
8. Marking Sevices Inc.
9. National Marker Company
10. Seton Identification Products
11. Stranco, Inc.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch-thick, and having predrilled holes for attachment hardware.

C. Letter Color: Black.

D. Background Color: Yellow.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2½-by-¾-inch.

G. Minimum Letter Size: ¼-inch for name of units if viewing distance is less than 24 inches, ½-inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

H. Fasteners: Stainless-steel rivets or self-tapping screws.

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

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

2.3 PIPE LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
2. Brady Corporation
3. Brimar Industries, Inc.
4. Carlton Industries, LP
5. Champion America
6. Craftmark Pipe Markers
7. emedco
8. Kolbi Pipe Marker Co.
9. LEM Products Inc.
10. Marking Sevices Inc.
11. Seton Identification Products

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: Size letters according to ASME A13.1 for piping.

2.4 VALVE TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
2. Brady Corporation
3. Brimar Industries, Inc.
4. Carlton Industries, LP
5. Champion America
6. Craftmark Pipe Markers
7. emedco
8. Kolbi Pipe Marker Co.
9. LEM Products Inc.
10. Marking Sevices Inc.
11. Seton Identification Products

B. Valve Tags: Stamped or engraved with ¼-inch letters for piping system abbreviation and ½-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link chain or S-hook.

C. Valve Schedules: For each piping system, on 8½-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

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

2.5 WARNING TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Brady Corporation
2. Brimar Industries, Inc.
3. Carlton Industries, LP

4. Champion America
5. Craftmark Pipe Markers.
6. emedco
7. Kolbi Pipe Marker Co.
8. LEM Products Inc.
9. Marking Sevices Inc.
10. Seton Identification Products

B. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.

1. Size: 3 by 5¼ inches minimum.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 GENERAL INSTALLATION REQUIREMENTS

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

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

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

3.3 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in Division 09.

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, with painted, color-coded bands or rectangles on each piping system.

1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

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

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

D. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

E. Pipe Label Color Schedule:

1. Domestic Water Piping

   a. Background: Safety green.
   b. Letter Colors: White.

2. Sanitary Waste and Storm Drainage Piping:

   a. Background Color: Safety gray.
   b. Letter Color: White.

3.5 VALVE-TAG INSTALLATION

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

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

   a. Cold Water: 2 inches, round.
   b. Hot Water: 2 inches, round.

2. Valve-Tag Colors:

   a. Cold Water: Safety green.
   b. Hot Water: Safety green.

3. Letter Colors:

   a. Cold Water: White.
   b. Hot Water: White.

3.6 WARNING-TAG INSTALLATION

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

END OF SECTION 220553

SECTION 220719 - PLUMBING PIPING INSULATION

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 insulating the following plumbing piping services:

1. Domestic cold-water piping.
2. Domestic hot-water piping.
3. Domestic recirculating hot-water piping.
4. Sanitary waste piping exposed to freezing conditions.
5. Storm-water piping exposed to freezing conditions.
6. Supplies and drains for handicap-accessible lavatories and sinks.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

1. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
2. Jacket Materials for Pipe: 12 inches long by NPS 2.
3. Sheet Jacket Materials: 12 inches square.
4. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation

materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

C. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless-steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless-steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Pittsburgh Corning Corporation

2. Block Insulation: ASTM C 552, Type I.
3. Special-Shaped Insulation: ASTM C 552, Type III.
4. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
5. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Aeroflex USA, Inc.
b. Armacell LLC
c. K-Flex USA

H. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. CertainTeed Corporation
b. Johns Manville; a Berkshire Hathaway company

c. Knauf Insulation
d. Manson Insulation Inc.
e. Owens Corning

I. Mineral-Fiber, Preformed Pipe Insulation:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Johns Manville; a Berkshire Hathaway company
b. Knauf Insulation
c. Manson Insulation Inc.
d. Owens Corning

2. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Ramco Insulation, Inc.

B. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Ramco Insulation, Inc.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Foster Brand; H. B. Fuller Construction Products

C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Aeroflex USA, Inc.
b. Armacell LLC
c. Foster Brand; H. B. Fuller Construction Products
d. K-Flex USA

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Childers Brand; H. B. Fuller Construction Products
b. Eagle Bridges - Marathon Industries
c. Foster Brand; H. B. Fuller Construction Products
d. Mon-Eco Industries, Inc.

E. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Childers Brand; H. B. Fuller Construction Products
b. Eagle Bridges - Marathon Industries
c. Foster Brand; H. B. Fuller Construction Products
d. Mon-Eco Industries, Inc.

F. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Dow Corning Corporation
b. Johns Manville; a Berkshire Hathaway company
c. P.I.C. Plastics, Inc.
d. Speedline Corporation

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Childers Brand; H. B. Fuller Construction Products
b. Eagle Bridges - Marathon Industries
c. Foster Brand; H. B. Fuller Construction Products
d. Mon-Eco Industries, Inc.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
3. Service Temperature Range: 0 to 180 deg F.
4. Solids Content: ASTM D 1644, forty-four percent (44%) by volume and sixty-two percent (62%) by weight.

5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Childers Brand; H. B. Fuller Construction Products
b. Eagle Bridges - Marathon Industries
c. Foster Brand; H. B. Fuller Construction Products

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Solids Content: ASTM D 1644, thirty-three percent (33%) by volume and forty-six percent (46%) by weight.
5. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Childers Brand; H. B. Fuller Construction Products
b. Foster Brand; H. B. Fuller Construction Products
c. Vimasco Corporation

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
4. Service Temperature Range: 0 to plus 180 deg F.
5. Color: White.

2.6 SEALANTS

A. Joint Sealants for Cellular-Glass Products:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Childers Brand; H. B. Fuller Construction Products
b. Eagle Bridges - Marathon Industries
c. Foster Brand; H. B. Fuller Construction Products
d. Mon-Eco Industries, Inc.
e. Pittsburgh Corning Corporation

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F.
5. Color: White or gray.

B. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Childers Brand; H. B. Fuller Construction Products

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Childers Brand; H. B. Fuller Construction Products

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Foster Brand; H. B. Fuller Construction Products
    b. Vimasco Corporation

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and pre-sized a minimum of 8 oz./sq. yd.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Alpha Associates, Inc.

2.10 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Johns Manville; a Berkshire Hathaway company
b. P.I.C. Plastics, Inc.
c. Proto Corporation
d. Speedline Corporation

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: Color-code jackets based on system. Color as selected by Architect and Owner from manufacturer's entire range.
4. 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. Underground Direct-Buried Jacket: 125-mil-thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Pittsburgh Corning Corporation
b. Polyguard Products, Inc.

2.11 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Avery Dennison Corporation, Specialty Tapes Division
b. Compac Corporation
c. Ideal Tape Co., Inc., an American Biltrite Company
d. Knauf Insulation
e. Venture Tape

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: Two percent (2%).
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Avery Dennison Corporation, Specialty Tapes Division
    b. Compac Corporation
    c. Ideal Tape Co., Inc., an American Biltrite Company
    d. Knauf Insulation
    e. Venture Tape

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: Two percent (2%).
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Compac Corporation
    b. Ideal Tape Co., Inc., an American Biltrite Company
    c. Venture Tape

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: Five hundred percent (500%).
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Avery Dennison Corporation, Specialty Tapes Division
    b. Compac Corporation
    c. Ideal Tape Co., Inc., an American Biltrite Company
    d. Knauf Insulation
    e. Venture Tape

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: Five percent (5%).
6. Tensile Strength: 34 lbf/inch in width.

2.12 SECUREMENTS

A. Bands:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. ITW Insulation Systems; Illinois Tool Works, Inc.
    b. RPR Products, Inc.

2. Stainless-Steel: ASTM A 167 or ASTM A 240, Type 316; 0.015-inch-thick, ¾-inch-wide with wing seal or closed seal.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020-inch-thick, ¾-inch-wide with wing seal or closed seal.

B. Staples: Outward-clinching insulation staples, nominal ¾-inch-wide, stainless-steel or Monel.

C. Wire: 0.062-inch soft-annealed, stainless-steel.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. C & F Wire

2.13 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Engineered Brass Company
    b. Insul-Tect Products Co.
    c. McGuire Manufacturing
    d. Plumberex Specialty Products, Inc.
    e. Truebro
    f. Zurn Industries, LLC

2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

B. Protective Shielding Piping Enclosures:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Truebro
    b. Zurn Industries, LLC

2. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1½ inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than seventy-five percent (75%) of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.

4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two (2) times the thickness of pipe insulation, or one (1) pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two (2) times the thickness of pipe insulation, or one (1) pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable

insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two (2) times the thickness of pipe insulation, or one (1) pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two (2) times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two (2) halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two (2) coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1-inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1-inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.9 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two (2) 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1½-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

1. Apply two (2) continuous beads of adhesive to seams and joints, one (1) bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.10 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below.

1. Flat Acrylic Finish: Two (2) finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two (2) coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect and Owner from manufacturer’s entire range. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections:

B. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three (3) locations of straight pipe, three (3) locations of threaded fittings, three (3) locations of welded fittings, two (2) locations of threaded strainers, two (2) locations of welded strainers, three (3) locations of threaded valves, and three (3) locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.12 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one (1) material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.13 PIPING INSULATION SCHEDULE

A. Refer to Schedule on Drawings.

3.14 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket. If more than one (1) material is listed, selection from materials listed is Contractor's option.

B. Piping, Concealed:

1. None.

C. Piping, Exposed:

1. PVC: 30 mils thick.

3.15 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 220719

SECTION 221116 - DOMESTIC WATER PIPING

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. Copper tube and fittings.
2. Ductile-iron pipe and fittings.
3. PEX tube and fittings.
4. Piping joining materials.
5. Encasement for piping.
6. Transition fittings.
7. Dielectric fittings.

1.3 ACTION SUBMITTALS

A. Product Data: For transition fittings and dielectric fittings.

1.4 INFORMATIONAL SUBMITTALS

A. System purging and disinfecting activities report.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Potable-water piping and components shall comply with NSF 14 and NSF 61 Annex G. Plastic piping components shall be marked with "NSF-pw."

C. Comply with NSF Standard 372 for low lead.

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.

B. Soft Copper Tube: ASTM B 88, Type K and ASTM B 88, Type L water tube, annealed temper.

C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

F. Copper Unions:

1. MSS SP-123.
2. Cast-copper-alloy, hexagonal-stock body.
3. Ball-and-socket, metal-to-metal seating surfaces.
4. Solder-joint or threaded ends.

G. Copper Pressure-Seal-Joint Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

   a. Apollo Valves; Conbraco Industries, Inc.
   b. Elkhart Products Corporation
   c. NIBCO INC.
   d. Viega LLC
   e. Mueller Industries

2. Fittings for NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber, O-ring seal in each end.
3. Fittings for NPS 2-1/2 to NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber, O-ring seal in each end.

H. Appurtenances for Grooved-End Copper Tubing:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

   a. Anvil International
   b. Grinnell Mechanical Products
   c. Shurjoint Piping Products
   d. Victaulic Company

2. Bronze Fittings for Grooved-End, Copper Tubing: ASTM B 75 copper tube or ASTM B 584 bronze castings.
3. Mechanical Couplings for Grooved-End Copper Tubing:

   a. Copper-tube dimensions and design similar to AWWA C606.
   b. Ferrous housing sections.
   c. EPDM-rubber gaskets suitable for hot and cold water.
   d. Bolts and nuts.
   e. Minimum Pressure Rating: 300 psig.

2.3 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe:

1. AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Standard-Pattern, Mechanical-Joint Fittings:

1. AWWA C110/A21.10, ductile or gray iron.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

C. Compact-Pattern, Mechanical-Joint Fittings:

1. AWWA C153/A21.53, ductile iron.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

D. Push-on-Joint, Ductile-Iron Pipe:

1. AWWA C151/A21.51.
2. Push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.

E. Standard-Pattern, Push-on-Joint Fittings:

1. AWWA C110/A21.10, ductile or gray iron.
2. Gaskets: AWWA C111/A21.11, rubber.

F. Compact-Pattern, Push-on-Joint Fittings:

1. AWWA C153/A21.53, ductile iron.
2. Gaskets: AWWA C111/A21.11, rubber.

G. Plain-End, Ductile-Iron Pipe: AWWA C151/A21.51.

H. Appurtenances for Grooved-End, Ductile-Iron Pipe:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Shurjoint Piping Products
    b. Smith-Cooper International
    c. Star Pipe Products
    d. Victaulic Company

2. Fittings for Grooved-End, Ductile-Iron Pipe: ASTM A 47, malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions that match pipe.
3. Mechanical Couplings for Grooved-End, Ductile-Iron-Piping:

    a. AWWA C606 for ductile-iron-pipe dimensions.
    b. Ferrous housing sections.
    c. EPDM-rubber gaskets suitable for hot and cold water.
    d. Bolts and nuts.
    e. Minimum Pressure Rating:

        1) NPS 14 to NPS 18: 250 psig.
        2) NPS 20 to NPS 46: 150 psig.

2.4 PEX TUBE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Apollo Valves; Conbraco Industries, Inc.
2. Elkhart Products Corporation
3. IPEX USA LLC
4. Uponor
5. Viega LLC
6. Watts Radiant; a Watts Water Technologies company
7. Zurn Industries, LLC

B. Tube Material: PEX plastic according to ASTM F 876 and ASTM F 877.

C. Fittings: ASTM F 1807, metal insert and copper crimp rings.

2.5 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:

1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
2. Full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys.

D. Flux: ASTM B 813, water flushable.

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

F. Plastic, Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.6 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105/A21.5.

B. Form: Sheet or tube.

C. Color: Black or natural.

2.7 TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Sleeve-Type Transition Coupling: AWWA C219.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Cascade Waterworks Mfg. Co.
b. Dresser, Inc.
c. Ford Meter Box Company, Inc. (The)
d. Jay R. Smith Mfg. Co.
e. JCM Industries, Inc.
f. Romac Industries, Inc.
g. Smith-Blair, Inc.
h. Viking Johnson

D. Plastic-to-Metal Transition Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Charlotte Pipe and Foundry Company
b. Harvel Plastics, Inc.
c. Spears Manufacturing Company
d. Uponor

2. Description:

a. CPVC or PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions.
b. One end with threaded brass insert and one solvent-cement-socket or threaded end.

E. Plastic-to-Metal Transition Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Colonial Engineering, Inc.
b. NIBCO INC.
c. Spears Manufacturing Company

2. Description:

a. CPVC or PVC four-part union.
b. Brass or stainless-steel threaded end.
c. Solvent-cement-joint or threaded plastic end.
d. Rubber O-ring.
e. Union nut.

2.8 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. A.Y. McDonald Mfg. Co.
b. Capitol Manufacturing Company

c. Central Plastics Company
d. HART Industrial Unions, LLC
e. Jomar Valve
f. Matco-Norca
g. Watts; a Watts Water Technologies company
h. Wilkins
i. Zurn Industries, LLC

2. Standard: ASSE 1079.
3. Pressure Rating: 125 psig minimum at 180 deg F.
4. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Capitol Manufacturing Company
b. Central Plastics Company
c. Matco-Norca
d. Watts; a Watts Water Technologies company
e. Wilkins
f. Zurn Industries, LLC

2. Standard: ASSE 1079.
3. Factory-fabricated, bolted, companion-flange assembly.
4. Pressure Rating: 125 psig minimum at 180 deg F.
5. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company
d. Pipeline Seal and Insulator, Inc.

2. Nonconducting materials for field assembly of companion flanges.
3. Pressure Rating: 150 psig.
4. Gasket: Neoprene or phenolic.
5. Bolt Sleeves: Phenolic or polyethylene.
6. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Elster Perfection Corporation
b. Grinnell Mechanical Products
c. Matco-Norca
d. Precision Plumbing Products

e. Victaulic Company

2. Standard: IAPMO PS 66.
3. Electroplated steel nipple complying with ASTM F 1545.
4. Pressure Rating and Temperature: 300 psig at 225 deg F.
5. End Connections: Male threaded or grooved.
6. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install underground ductile-iron pipe in PE encasement according to ASTM A 674 or AWWA C105/A21.5.

E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 221119 "Domestic Water Piping Specialties."

F. Install shutoff valve immediately upstream of each dielectric fitting.

G. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 221119 "Domestic Water Piping Specialties."

H. Install domestic water piping level without pitch and plumb.

I. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

J. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

K. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

L. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

M. Install piping to permit valve servicing.

N. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

O. Install piping free of sags and bends.

P. Install fittings for changes in direction and branch connections.

Q. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

R. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping."

S. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 221123 "Domestic Water Pumps."

T. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 220519 "Meters and Gages for Plumbing Piping."

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

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

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

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.

E. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

F. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.

G. Joint Construction for Grooved-End Copper Tubing: Make joints according to AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.

H. Joint Construction for Grooved-End, Ductile-Iron Piping: Make joints according to AWWA C606. Cut round-bottom grooves in ends of pipe at gasket-seat dimension required for specified (flexible or rigid) joint. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket with keys seated in piping grooves. Install and tighten housing bolts.

I. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

J. Joints for PEX Tubing: Join according to ASTM F 1807 for metal insert and copper crimp ring fittings and ASTM F 1960 for cold expansion fittings and reinforcing rings.

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

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.
2. Fittings for NPS 2 and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings or unions.

3.5 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.

C. Dielectric Fittings for NPS 2-1/2 and larger: Use dielectric flanges or flange kits.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger, support products, and installation in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:

a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one (1) size for double-rod hangers, to a minimum of 3/8-inch.

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
4. NPS 2-1/2: 108 inches with ½-inch rod.

F. Install supports for vertical copper tubing every 10 feet.

G. Install vinyl-coated hangers for PEX tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1 and Smaller: 32 inches with 3/8-inch rod.

H. Install hangers for vertical PEX tubing every 48 inches.

I. Support piping and tubing not listed in this article according to MSS SP-58 and manufacturer's written instructions.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:

1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
2. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
3. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.8 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Label pressure piping with system operating pressure.

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Piping Inspections:

a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
b. During installation, notify authorities having jurisdiction at least one (1) day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.

c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

2. Piping Tests:

a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for 4 hours. Leaks and loss in test pressure constitute defects that must be repaired.
e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.

    a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
    b. Adjust calibrated balancing valves to flows indicated.

5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

A. Clean and disinfect potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:

    a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
    b. Fill and isolate system according to either of the following:

        1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
        2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for 3 hours.

    c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
    d. Repeat procedures if biological examination shows contamination.
    e. Submit water samples in sterile bottles to authorities having jurisdiction.

B. Clean non-potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:

    a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
    b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

C. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

D. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.12 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

D. Refer to Schedule on Drawings.

3.13 VALVE SCHEDULE

A. Refer to Schedule on Drawings.

END OF SECTION 221116

SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

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. Vacuum breakers.
2. Backflow preventers.
3. Balancing valves.
4. Thermostatic mixing valve.
5. Strainers.
6. Wall hydrants.
7. Drain valves.
8. Water-hammer arresters.
9. Trap-seal primer valves.
10. Trap-seal primer systems.
11. Specialty valves.
12. Flexible connectors.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.

1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Potable-water piping and components shall comply with NSF 61 Annex G and NSF 14. Mark "NSF-pw" on plastic piping components.

2.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.3 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Ames Co.
b. Ames Fire & Waterworks
c. Apollo Valves; Conbraco Industries, Inc.
d. Cash Acme
e. FEBCO
f. Rain Bird Corporation
g. Toro Company (The)
h. Watts; a Watts Water Technologies company
i. Zurn Industries, LLC

2. Standard: ASSE 1001.
3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
4. Body: Bronze.
5. Inlet and Outlet Connections: Threaded.
6. Finish: Chrome plated.

B. Hose-Connection Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Apollo Valves; Conbraco Industries, Inc.
b. Arrowhead Brass Products
c. Cash Acme
d. Legend Valve & Fitting, Inc.
e. MIFAB, Inc.
f. Prier Products, Inc.
g. Watts; a Watts Water Technologies company
h. Woodford Manufacturing Company
i. Zurn Industries, LLC

2. Standard: ASSE 1011.
3. Body: Bronze, nonremovable, with manual drain.
4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
5. Finish: Rough bronze.

C. Pressure Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Ames Co.
b. Ames Fire & Waterworks

c. Apollo Valves; Conbraco Industries, Inc.
d. FEBCO
e. Flomatic Corporation
f. Toro Company (The)
g. Watts; a Watts Water Technologies company
h. Zurn Industries, LLC

2. Standard: ASSE 1020.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 5 psig maximum, through middle third of flow range.
5. Accessories:

a. Valves: Ball type, on inlet and outlet.

D. Spill-Resistant Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Apollo Valves; Conbraco Industries, Inc.
b. Watts; a Watts Water Technologies company
c. Zurn Industries, LLC

2. Standard: ASSE 1056.
3. Operation: Continuous-pressure applications.
4. Accessories:

a. Valves: Ball type, on inlet and outlet.

2.4 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Ames Co.
b. Ames Fire & Waterworks
c. Apollo Valves; Conbraco Industries, Inc.
d. FEBCO
e. Flomatic Corporation
f. Watts; a Watts Water Technologies company
g. Zurn Industries, LLC.

2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle third of flow range.
5. Refer to drawing schedules for capacity and characteristics.
6. Accessories:

a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

B. Beverage-Dispensing-Equipment Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

   a. Apollo Valves; Conbraco Industries, Inc.
   b. Watts; a Watts Water Technologies company
   c. Zurn Industries, LLC

2. Standard: ASSE 1022.
3. Operation: Continuous-pressure applications.
4. Size: NPS 1/4 or NPS 3/8.
5. Body: Stainless-steel.
6. End Connections: Threaded.

C. Reduced-Pressure-Detector, Fire-Protection, Backflow-Preventer Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

   a. Ames Co.
   b. Ames Fire & Waterworks
   c. Apollo Valves; Conbraco Industries, Inc.
   d. FEBCO
   e. Watts; a Watts Water Technologies company
   f. Zurn Industries, LLC

2. Standard: ASSE 1047 and is FM Global approved or UL listed.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle third of flow range.
5. Refer to Schedules on Drawings for capacity and characteristics.
6. Accessories:

   a. Valves: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
   b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.
   c. Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.

D. Hose-Connection Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

   a. Apollo Valves; Conbraco Industries, Inc.
   b. Watts; a Watts Water Technologies company
   c. Woodford Manufacturing Company

2. Standard: ASSE 1052.
3. Operation: Up to 10-foot head of water back pressure.
4. Inlet Size: NPS 1/2 or NPS 3/4.
5. Outlet Size: Garden-hose thread complying with ASME B1.20.7.
6. Capacity: At least 3-gpm flow.

E. Backflow-Preventer Test Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Apollo Valves; Conbraco Industries, Inc.
    b. FEBCO
    c. Flomatic Corporation
    d. Watts; a Watts Water Technologies company
    e. Zurn Industries, LLC

2. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.5 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Apollo Valves; Conbraco Industries, Inc.
    b. Cash Acme
    c. Honeywell Water Controls
    d. Watts; a Watts Water Technologies company
    e. Zurn Industries, LLC

2. Standard: ASSE 1003.
3. Pressure Rating: Initial working pressure of 150 psig.
4. Valves for Booster Heater Water Supply: Include integral bypass.
5. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

2.6 BALANCING VALVES

A. Copper-Alloy Calibrated Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Armstrong International, Inc.
    b. Flo Fab Inc.
    c. ITT Corporation
    d. NIBCO INC.
    e. Schneider Electric USA, Inc.
    f. TACO Incorporated
    g. Watts; a Watts Water Technologies company

2. Type: Ball or Y-pattern globe valve with two (2) readout ports and memory-setting indicator.
3. Body: Bronze.
4. Size: Same as connected piping, but not larger than NPS 2.
5. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

2.7 SELF ACTUATING THERMOSTATIC BALANCING VALVE (SATBV)

A. Basis-of-Design: Furnish and install **CircuitSolver** as indicated on the plans. **CircuitSolver** shall be self-contained and fully automatic without additional piping or control mechanisms.

Valve shall be **CircuitSolver** as manufactured by ThermOmegaTech, Inc., or equivalent by approved manufacturer.

1. SATBV device shall regulate the flow of recirculated domestic hot water based on water temperature entering the SATBV regardless of system operating pressure.

    a. Even when fully closed the SATBV shall bypass a small amount hot water to maintain dynamic control of the recirculating loop.
    b. SATBV shall be factory adjustable as required by project conditions.
    c. SATBV shall be available in sizes ranging from 1/2” NPT to 2” NPT.

2. SATBV device’s body and all internal components shall be constructed of stainless-steel with major components constructed of type 303 stainless-steel.

    a. SATBV sizes ½-inch through 2-inch shall be rated to 200 psig maximum working pressure.

        1) All SATBV shall be standard tapered female pipe thread, NPT.

    b. All SATBV shall be rated to 300°F (148.9°C) maximum working temperature.
    c. All SATBV shall be NSF-61 certified for use in all domestic water systems.
    d. Thermal actuator shall be spring loaded and self cleaning, delivering closing thrust sufficient to keep orifice opening free of scale deposits.

3. Installation of **CircuitSolver** shall be made by qualified tradesmen. Install SATBV in each domestic hot water return piping branch beyond last hot water device in that branch.

    a. Provide suitable line size isolation valves, unions, and strainer as indicated in piping detail shown on the Drawings.
    b. Provide suitable access panel as required in non-accessible ceilings and walls.

2.8 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Primary, Thermostatic, Water Mixing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Acorn Engineering Company
    b. Apollo Valves; Conbraco Industries, Inc.
    c. Armstrong International, Inc.
    d. Lawler Manufacturing Company, Inc.
    e. Leonard Valve Company
    f. Powers
    g. Symmons Industries, Inc.

2. Standard: ASSE 1017.
3. Pressure Rating: 125 psig minimum unless otherwise indicated.
4. Type: Exposed-mounted, thermostatically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded union inlets and outlet.
7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Refer to Schedules on Drawings for capacity and characteristics.

B. Individual-Fixture, Water Tempering Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

   a. Acorn Engineering Company
   b. Apollo Valves; Conbraco Industries, Inc.
   c. Lawler Manufacturing Company, Inc.
   d. Leonard Valve Company
   e. Powers
   f. Watts; a Watts Water Technologies company
   g. Zurn Industries, LLC

2. Standard: ASSE 1070, thermostatically controlled, water tempering valve.
3. Pressure Rating: 125 psig minimum unless otherwise indicated.
4. Body: Bronze body with corrosion-resistant interior components.
5. Temperature Control: Adjustable.
6. Inlets and Outlet: Threaded.
7. Finish: Rough or chrome-plated bronze.
8. Refer to Schedules on Drawings for capacity and characteristics.

2.9 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless-steel with round perforations unless otherwise indicated.
5. Drain: Factory-installed, hose-end drain valve.

2.10 WALL HYDRANTS

A. Non-freeze Wall Hydrants:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

   a. Jay R. Smith Mfg. Co.
   b. Josam Company
   c. MIFAB, Inc.
   d. Prier Products, Inc.
   e. Tyler Pipe; a subsidiary of McWane Inc.
   f. Watts; a Watts Water Technologies company
   g. Woodford Manufacturing Company
   h. Zurn Industries, LLC

2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig.
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1.

7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounted with cover.
9. Box and Cover Finish: Polished nickel bronze.
10. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
11. Nozzle and Wall-Plate Finish: Polished nickel bronze.
12. Operating Keys(s): Two (2) with each wall hydrant.

2.11 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

B. Gate-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-80 for gate valves.
2. Pressure Rating: Class 125.
3. Size: NPS 3/4.
4. Body: ASTM B 62 bronze.
5. Inlet: NPS 3/4 threaded or solder joint.
6. Outlet: Garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

C. Stop-and-Waste Drain Valves:

1. Standard: MSS SP-110 for ball valves or MSS SP-80 for gate valves.
2. Pressure Rating: 200-psig minimum CWP or Class 125.
3. Size: NPS 3/4.
4. Body: Copper alloy or ASTM B 62 bronze.
5. Drain: NPS 1/8 side outlet with cap.

2.12 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. AMTROL, Inc.
b. Jay R. Smith Mfg. Co.
c. Josam Company
d. MIFAB, Inc.
e. Precision Plumbing Products
f. Sioux Chief Manufacturing Company, Inc.
g. Tyler Pipe; a subsidiary of McWane Inc.

h. Watts; a Watts Water Technologies company
i. Zurn Industries, LLC

2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.13 TRAP-SEAL PRIMER SYSTEMS

A. Trap-Seal Primer Systems:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Precision Plumbing Products
b. Zurn Industries, LLC

2. Standard: ASSE 1044.
3. Piping: NPS 3/4, ASTM B 88, Type L; copper, water tubing.
4. Cabinet: Recessed or surface-mounted steel box with stainless-steel cover.
5. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac power.

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

6. Vacuum Breaker: ASSE 1001.
7. Number Outlets: Four (4).
8. Size Outlets: NPS 1/2.

2.14 TRAP SEAL PROTECTION DEVICES

A. Barrier Type Trap Seal Protection Devices:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
b. SureSeal Manufacturing
c. Provent Systems Inc.

2. Standard: ASSE 1072-2007.
3. Body: ASB plastic.
4. Diaphragm and Sealing Gasket: Neoprene rubber.
5. Size: 2-, 3-, or 4-inch.
6. Gravity Drain Outlet Connection: Compression fit sealing gasket 80 durometer.

2.15 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Flex Pression Ltd.
2. Flex-Hose Co., Inc.

3. Flexicraft Industries
4. Flex-Weld, Inc.
5. Hyspan Precision Products, Inc.
6. Mercer Gasket & Shim, Inc.
7. Metraflex Company (The)
8. Proco Products, Inc.
9. Tozen Corporation
10. Unaflex
11. Universal Metal Hose

B. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig.
2. End Connections NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
3. End Connections NPS 2-1/2 and Larger: Flanged copper alloy.

C. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig.
2. End Connections NPS 2 and Smaller: Threaded steel-pipe nipple.
3. End Connections NPS 2-1/2 and Larger: Flanged steel nipple.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.
2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two (2) pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
3. Do not install bypass piping around backflow preventers.

B. Install balancing valves in locations where they can easily be adjusted.

C. Install temperature-actuated, water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.

1. Install cabinet-type units recessed in or surface mounted on wall as specified.

D. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.

E. Install water-hammer arresters in water piping according to PDI-WH 201.

3.2 CONNECTIONS

A. Comply with requirements for ground equipment in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Fire-retardant-treated-wood blocking is specified in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical connections.

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Backflow preventers.
2. Thermostatic, water mixing valves.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test each backflow preventer according to authorities having jurisdiction and the device's reference standard.

B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Set field-adjustable flow set points of balancing valves.

B. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION 221119

SECTION 221123 - DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. In-line, sealless centrifugal pumps.

1.3 DEFINITIONS

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include materials of construction, rated capacities, certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water pumps to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

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

B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 IN-LINE, SEALLESS CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Flo Fab Inc.
2. Grundfos Pumps Corp.
3. TACO Comfort Solutions, Inc.
4. WILO USA LLC - WILO Canada Inc.

B. Description: Factory-assembled and -tested, in-line, close-coupled, canned-motor, sealless, overhung-impeller centrifugal pumps.

C. Pump Construction:

1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge type with motor and impeller on common shaft and designed for installation with pump and motor shaft horizontal.
2. Casing: Bronze, with threaded or companion-flange connections.
3. Impeller: Plastic.
4. Motor: Single speed, unless otherwise indicated.

D. Capacities and Characteristics:

1. Refer to Schedules on Drawings for pump requirements.

2.2 INLINE PUMP

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Alyan Pump Company
2. Armstrong Pumps, Inc.
3. Bell & Gossett; a Xylem brand
4. Flo Fab Inc.
5. Grundfos Pumps Corp.
6. Marshall Engineered Products Co.
7. PACO Pumps; Grundfos Pumps Corporation, USA
8. Pentair Pump Group
9. TACO Comfort Solutions, Inc.
10. Thrush Co. Inc.
11. Weinman Division

B. Description: Factory-assembled and -tested, in-line, single-stage, close-coupled, overhung-impeller centrifugal pumps designed for installation with pump and motor shaft mounted vertical.

C. Pump Construction:

1. Casing: Radially split, cast iron, with wear rings and threaded companion-flange connections for pumps with NPS 2 pipe connections and flanged connections for pumps with NPS 2-1/2 pipe connections. Include pump manufacturer's base attachment for mounting pump on concrete base.
2. Impeller: Statically and dynamically balanced, closed, and keyed to shaft.

3. Shaft and Shaft Sleeve: Stainless-steel shaft, with copper-alloy shaft sleeve.
4. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.
5. Bearings: Oil-lubricated; bronze-journal or ball type.
6. Shaft Coupling: Flexible or rigid type if pump is provided with coupling.

D. Motor: Single speed, with grease-lubricated ball bearings; rigidly mounted to pump casing.

E. Capacities and Characteristics:

1. Refer to Schedules on Drawings for pump requirements.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.4 CONTROLS

A. Thermostats: Electric; adjustable for control of hot-water circulation pump.

1. Type: Water-immersion temperature sensor, for installation in piping.
2. Range: 65 to 200 deg F.
3. Enclosure: NEMA 250, Type 4X.
4. Operation of Pump: On or off.
5. Transformer: Provide if required.
6. Power Requirement: 120 V, ac.
7. Settings: Start pump at 115 deg F and stop pump at 120 F.

B. Timers: Electric, for control of hot-water circulation pump.

1. Type: Programmable, seven-day clock with manual override on-off switch.
2. Enclosure: NEMA 250, Type 1, suitable for wall mounting.
3. Operation of Pump: On or off.
4. Transformer: Provide if required.
5. Power Requirement: 120-V ac.
6. Programmable Sequence of Operation: Up to two (2) on-off cycles each day for seven (7) days.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump installation.

3.2 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install in-line, sealless centrifugal pumps with shaft horizontal unless otherwise indicated.

C. Install vertically mounted, in-line, close-coupled centrifugal pumps with shaft vertical.

D. Install continuous-thread hanger rods and spring hangers with vertical-limit stop of size required to support pump weight.

1. Comply with requirements for vibration isolation devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment." Fabricate brackets or supports as required.
2. Comply with requirements for hangers and supports specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

E. Install pressure switches in water supply piping.

F. Install thermostats in hot-water return piping.

G. Install timers in mechanical room.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to pumps to allow service and maintenance.

C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.

1. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:

a. Horizontally mounted, in-line, separately coupled centrifugal pumps.
b. Horizontally mounted, in-line, close-coupled centrifugal pumps.
c. Vertically mounted, in-line, close-coupled centrifugal pumps.
d. Comply with requirements for flexible connectors specified in Section 221116 "Domestic Water Piping."

D. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for valves specified in Sections 220523.12 "Ball Valves for Plumbing Piping," 220523.14 "Check Valves for Plumbing Piping," and 220523.15 "Gate Valves for Plumbing Piping," and comply with requirements for strainers specified in Section 221119 "Domestic Water Piping Specialties."

1. Install pressure gage and snubber at suction of each pump and pressure gage and snubber at discharge of each pump. Install at integral pressure-gage tappings where provided or install pressure-gage connectors in suction and discharge piping around pumps. Comply with requirements for pressure gages and snubbers specified in Section 220519 "Meters and Gages for Plumbing Piping."

E. Connect pressure switches, thermostats, time-delay relays, and timers to pumps that they control.

3.4 IDENTIFICATION

A. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment" for identification of pumps.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Set pressure switches, thermostats, timers, and time-delay relays for automatic starting and stopping operation of pumps.
5. Perform the following startup checks for each pump before starting:

    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in the correct direction.

6. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
7. Start motor.
8. Open discharge valve slowly.
9. Adjust temperature settings on thermostats.
10. Adjust timer settings.

3.6 ADJUSTING

A. Adjust domestic water pumps to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust initial temperature set points.

C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

END OF SECTION 221123

SECTION 221316 - SANITARY WASTE AND VENT PIPING

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. Pipe, tube, and fittings.
2. Specialty pipe fittings.
3. Encasement for underground metal piping.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For hubless, single-stack drainage system. Include plans, elevations, sections, and details.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For waste and vent piping, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.5 FIELD CONDITIONS

A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify Architect, Construction Manager, and Owner no fewer than two (2) days in advance of proposed interruption of sanitary waste service.
2. Do not proceed with interruption of sanitary waste service without Construction Manager's and Owner's written permission.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Soil, Waste, and Vent Piping: 10-foot head of water.
2. Waste, Force-Main Piping: 50 psig.

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

2.2 PIPING MATERIALS

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.3 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, Service and Extra Heavy class(es).

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.4 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Heavy-Duty, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. ANACO-Husky
b. Charlotte Pipe and Foundry Company
c. Clamp-All Corp.
d. Mission Rubber Company, LLC; a division of MCP Industries
e. Tyler Pipe; a subsidiary of McWane Inc.

2. Standards: ASTM C 1277 and ASTM C 1540.
3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.5 PVC PIPE AND FITTINGS (NOT FOR KITCHEN APPLICATIONS)

A. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

B. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

C. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

D. Adhesive Primer: ASTM F 656.

E. Solvent Cement: ASTM D 2564.

2.6 VRF / COOLING COIL CONDENSATE DRAIN PIPING

A. If more than one material is listed, material selection is Contractor's option.

B. PRE-INSULATED PEX Tube:
1. Source Limitations: Obtain PEX tube from single manufacturer.
2. Tube Material: PEX plastic in accordance with ASTM F876 and ASTM F877.
3. ½" microcellular foam insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials. Flame-spread index of 25 or less, and smoke-developed index of 50 or less

C. PRE-INSULATED PEX Tube Fittings:
1. Source Limitations: Obtain PEX tube fittings from single manufacturer.
2. Fittings: ASTM F1807, metal insert and copper crimp rings.
3. Push-Fit Fittings: ASSE 1061, push-fit fittings.
4. ½" microcellular foam insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials. Flame-spread index of 25 or less, and smoke-developed index of 50 or less

D. Discharge from condensate pump for individual VRF / fan coil unit to gravity condensate drain line: Polyethylene, polypropylene, or PVDF pipe or tubing provided with in-line check valve. Gravity drain shall not be flexible tubing.

E. Drain size in accordance with the International Plumbing Code:

EQUIPMENT CAPACITY	MINIMUM CONDENSATE PIPE DIAMETER (inch)
Up to 20 tons of refrigeration	3/4 inch
Over 20 tons to 40 tons of refrigeration	1 inch
Over 40 tons to 90 tons of refrigeration	1 1/4 inches
Over 90 tons to 125 tons of refrigeration	1 1/2 inches
Over 125 tons to 250 tons of refrigeration	2 inches

For SI: 1 inch = 25.4 mm, 1 ton of capacity = 3.517 kW.

2.7 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
2. Unshielded, Non-pressure Transition Couplings:

a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1) Dallas Specialty & Mfg. Co.
2) Fernco Inc.
3) Froet Industries LLC
4) Mission Rubber Company, LLC; a division of MCP Industries

5) Plastic Oddities

b. Standard: ASTM C 1173.
c. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
d. End Connections: Same size as and compatible with pipes to be joined.
e. Sleeve Materials:

1) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

3. Shielded, Non-pressure Transition Couplings:

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1) Cascade Waterworks Mfg. Co.
2) Mission Rubber Company, LLC; a division of MCP Industries

b. Standard: ASTM C 1460.
c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
d. End Connections: Same size as and compatible with pipes to be joined.

4. Pressure Transition Couplings:

a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1) Cascade Waterworks Mfg. Co.
2) Dresser, Inc.
3) EBAA Iron, Inc.
4) Ford Meter Box Company, Inc. (The)
5) Jay R. Smith Mfg. Co.
6) JCM Industries, Inc.
7) Romac Industries, Inc.
8) Viking Johnson

b. Standard: AWWA C219.
c. Description: Metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
d. Center-Sleeve Material: Manufacturer's standard.
e. Gasket Material: Natural or synthetic rubber.
f. Metal Component Finish: Corrosion-resistant coating or material.

B. Dielectric Fittings:

1. Dielectric Unions:

a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1) A.Y. McDonald Mfg. Co.
2) Capitol Manufacturing Company
3) Central Plastics Company
4) HART Industrial Unions, LLC
5) Jomar Valve
6) Matco-Norca
7) Watts; a Watts Water Technologies company
8) Wilkins
9) Zurn Industries, LLC

b. Description:

1) Standard: ASSE 1079.
2) Pressure Rating: 125 psig minimum at 180 deg F.
3) End Connections: Solder-joint copper alloy and threaded ferrous.

2. Dielectric Flanges:

a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1) Capitol Manufacturing Company
2) Central Plastics Company
3) Matco-Norca
4) Watts; a Watts Water Technologies company
5) Wilkins
6) Zurn Industries, LLC

b. Description:

1) Standard: ASSE 1079.
2) Factory-fabricated, bolted, companion-flange assembly.
3) Pressure Rating: 125 psig minimum at 180 deg F.
4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

3. Dielectric-Flange Insulating Kits:

a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1) Advance Products & Systems, Inc.
2) Calpico, Inc.
3) Central Plastics Company
4) Pipeline Seal and Insulator, Inc.

b. Description:

1) Nonconducting materials for field assembly of companion flanges.
2) Pressure Rating: 150 psig.
3) Gasket: Neoprene or phenolic.
4) Bolt Sleeves: Phenolic or polyethylene.

5) Washers: Phenolic with steel backing washers.

4. Dielectric Nipples:

a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1) Elster Perfection Corporation
2) Grinnell Mechanical Products
3) Matco-Norca
4) Precision Plumbing Products
5) Victaulic Company

b. Description:

1) Standard: IAPMO PS 66.
2) Electroplated steel nipple.
3) Pressure Rating: 300 psig at 225 deg F.
4) End Connections: Male threaded or grooved.
5) Lining: Inert and noncorrosive, propylene.

2.8 ENCASEMENT FOR UNDERGROUND METAL PIPING

A. Standard: ASTM A 674 or AWWA C105/A 21.5.

B. Material: Linear low-density polyethylene film of 0.008-inch or high-density, cross-laminated polyethylene film of 0.004-inch minimum thickness.

C. Form: Sheet or tube.

D. Color: Black or natural.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.

1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
2. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.

1. Sanitary tees and short-sweep ¼ bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.
2. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back-to-back or side by side with common drain pipe.

    a. Straight tees, elbows, and crosses may be used on vent lines.

3. Do not change direction of flow more than 90 degrees.
4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.

    a. Reducing size of waste piping in direction of flow is prohibited.

K. Lay buried building waste piping beginning at low point of each system.

1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Maintain swab in piping and pull past each joint as completed.

L. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Waste: Two percent (2%) downward in direction of flow for piping NPS 3 and smaller; two percent (2%) downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Sanitary Waste Piping: Two percent (2%) downward in direction of flow.
3. Vent Piping: One percent (1%) down toward vertical fixture vent or toward vent stack.

M. 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. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.

N. Install aboveground PVC piping according to ASTM D 2665.

O. Install underground PVC piping according to ASTM D 2321.

P. Plumbing Specialties:

1. Install backwater valves in sanitary waster gravity-flow piping.

a. Comply with requirements for backwater valves specified in Section 221319 "Sanitary Waste Piping Specialties."

2. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.

a. Comply with requirements for cleanouts specified in Section 221319 "Sanitary Waste Piping Specialties."

3. Install drains in sanitary waste gravity-flow piping.

a. Comply with requirements for drains specified in Section 221319 "Sanitary Waste Piping Specialties."

Q. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

R. Install sleeves for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

S. Install sleeve seals for piping penetrations of concrete walls and slabs.

1. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

T. Install escutcheons for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. 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.

B. Join hub-and-spigot, cast-iron soil piping with caulked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum caulked joints.

C. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1.

1. Cut threads full and clean using sharp dies.

2. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

    a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
    b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
    c. Do not use pipe sections that have cracked or open welds.

E. Plastic, Non-Pressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 appendixes.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in ODs.
2. In Waste Drainage Piping: Shielded, non-pressure transition couplings.

B. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.
3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.
4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 VALVE INSTALLATION

A. Comply with requirements in Sections 220523.12 "Ball Valves for Plumbing Piping," 220523.14 "Check Valves for Plumbing Piping," and 220523.15 "Gate Valves for Plumbing Piping" for general-duty valve installation requirements.

B. Shutoff Valves:

1. Install shutoff valve on each sewage pump discharge.
2. Install gate or full-port ball valve for piping NPS 2 and smaller.
3. Install gate valve for piping NPS 2-1/2 and larger.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
5. Vertical Piping: MSS Type 8 or Type 42, clamps.

6. Install individual, straight, horizontal piping runs:

    a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.

7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
8. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one (1) size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with ½-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.

G. Install supports for vertical cast-iron soil piping every 15 feet.

H. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
2. NPS 3: 48 inches with ½-inch rod.
3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
4. NPS 6 and NPS 8: 48 inches with ¾-inch rod.

I. Install supports for vertical PVC piping every 48 inches.

J. Support piping and tubing not listed above according to MSS SP-58 and manufacturer's written instructions.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect waste and vent piping to the following:

1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.

5. Comply with requirements for cleanouts and drains specified in Section 221319 "Sanitary Waste Piping Specialties."
6. Equipment: Connect waste piping as indicated.

    a. Provide shutoff valve if indicated and union for each connection.
    b. Use flanges instead of unions for connections NPS 2-1/2 and larger.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Make connections according to the following unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping.

B. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary waste and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.

    a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced waste and vent piping until it has been tested and approved.

    a. Expose work that was covered or concealed before it was tested.

3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.

a. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.
b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
c. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight.

a. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg.
b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
c. Air pressure must remain constant without introducing additional air throughout period of inspection.
d. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.10 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

D. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two (2) coats of water-based latex paint.

E. Repair damage to adjacent materials caused by waste and vent piping installation.

3.11 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Refer to Schedules on Drawings.

END OF SECTION 221316

SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

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. Cleanouts.
2. Air-admittance valves.
3. Roof flashing assemblies.
4. Miscellaneous sanitary drainage piping specialties.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene.

B. FOG: Fats, oils, and greases.

C. PVC: Polyvinyl chloride.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, and accessories for the following:

1. FOG disposal systems.

B. Shop Drawings:

1. Show fabrication and installation details for frost-resistant vent terminals.
2. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For FOG disposal systems, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sanitary waste piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for plastic sanitary waste piping specialty components.

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

2.2 CLEANOUTS

A. Cast-Iron Exposed Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Jay R. Smith Mfg. Co.
    b. Josam Company
    c. MIFAB, Inc.
    d. Tyler Pipe; a subsidiary of McWane Inc.
    e. Watts; a Watts Water Technologies company
    f. Zurn Industries, LLC

2. Standard: ASME A112.36.2M.
3. Size: Same as connected drainage piping
4. Body Material: Hub-and-spigot, cast-iron soil pipe T-branch as required to match connected piping.
5. Closure: Countersunk or raised-head plug.
6. Closure Plug Size: Same as or not more than one (1) size smaller than cleanout size.
7. Refer to Schedules on Drawings for characteristics.

B. Stainless-Steel Exposed Cleanouts:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

    a. Josam Company

2. Standard: ASME A112.3.1.
3. Size: Same as connected drainage piping
4. Body Material: Stainless-steel tee with side cleanout as required to match connected piping.
5. Closure: Stainless-steel plug with seal.

C. Cast-Iron Exposed Floor Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Jay R. Smith Mfg. Co.
    b. Josam Company
    c. Oatey
    d. Sioux Chief Manufacturing Company, Inc.
    e. Tyler Pipe; a subsidiary of McWane Inc.
    f. Watts; a Watts Water Technologies company
    g. Zurn Industries, LLC

2. Standard: ASME A112.36.2M
3. Refer to Schedules on Drawings for characteristics.

D. Stainless-Steel Exposed Floor Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Josam Company
    b. Kusel Equipment Co.
    c. Zurn Industries, LLC

2. Standard: ASME A112.3.1.
3. Size: Same as connected branch.
4. Housing: Stainless-steel.
5. Closure: Stainless-steel with seal.
6. Refer to Schedules on Drawings for characteristics.

E. Cast-Iron Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Jay R. Smith Mfg. Co.
    b. Josam Company
    c. MIFAB, Inc.
    d. Tyler Pipe; a subsidiary of McWane Inc.
    e. Watts; a Watts Water Technologies company
    f. Zurn Industries, LLC

2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hub-and-spigot, cast-iron soil pipe T-branch as required to match connected piping.
5. Refer to Schedules on Drawings for characteristics.

2.3 AIR-ADMITTANCE VALVES

A. Fixture Air-Admittance Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Ayrlett, LLC

b. Durgo, Inc.
c. Oatey
d. ProSet Systems Inc.
e. RectorSeal
f. Studor, Inc.

2. Standard: ASSE 1051, Type A for single fixture or Type B for branch piping.
3. Housing: Plastic.
4. Operation: Mechanical sealing diaphragm.
5. Size: Same as connected fixture or branch vent piping.

B. Wall Box for Air-Admittance Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Durgo, Inc.
b. Oatey
c. RectorSeal
d. Studor, Inc.
e. Zurn Industries, LLC

2. Description: White plastic housing with white plastic grille, made for recessed installation. Include bottom pipe connection and space to contain one (1) air-admittance valve.
3. Size: About 9 inches wide by 8 inches high by 4 inches deep.

2.4 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Acorn Engineering Company
b. Thaler Metal Industries Ltd.
c. Zurn Industries, LLC

2. Description: Manufactured assembly made of 6.0-lb./sq. ft., 0.0938-inch-thick, lead flashing collar and skirt extending at least 8 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.

a. Open-Top Vent Cap: Without cap.
b. Low-Silhouette Vent Cap: With vandal-proof vent cap.
c. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.5 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:

1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564 rubber gaskets.
2. Size: Same as connected waste piping with increaser fitting of size indicated**.**

B. Deep-Seal Traps:

1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
2. Size: Same as connected waste piping.

    a. NPS 2: 4-inch-minimum water seal.
    b. NPS 2-1/2 and Larger: 5-inch-minimum water seal.

C. Floor-Drain, Trap-Seal Primer Fittings:

1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

D. Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

E. Sleeve Flashing Device:

1. Description: Manufactured, cast-iron fitting, with clamping device that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 2 inches above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

F. Stack Flashing Fittings:

1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. Size: Same as connected stack vent or vent stack.

G. Vent Caps:

1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
2. Size: Same as connected stack vent or vent stack.

H. Frost-Resistant Vent Terminals:

1. Description: Manufactured or shop-fabricated assembly constructed of copper, lead-coated copper, or galvanized steel.
2. Design: To provide 1-inch enclosed air space between outside of pipe and inside of flashing collar extension, with counterflashing.

I. Expansion Joints:

1. Standard: ASME A112.6.4.
2. Body: Cast iron with bronze sleeve, packing, and gland.
3. End Connections: Matching connected piping.

4. Size: Same as connected soil, waste, or vent piping.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

D. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof. Comply with requirements in Section 076200 "Sheet Metal Flashing and Trim."

E. Assemble open drain fittings and install with top of hub 2 inches above floor.

F. Install deep-seal traps on floor drains and other waste outlets, if indicated.

G. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.

1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
2. Size: Same as floor drain inlet.

H. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

I. Install sleeve and sleeve seals with each riser and stack passing through floors with waterproof membrane.

J. Install vent caps on each vent pipe passing through roof.

K. Install frost-resistant vent terminals on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.

L. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

M. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.

N. Install wood-blocking reinforcement for wall-mounting-type specialties.

O. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 CONNECTIONS

A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

3.3 FLASHING INSTALLATION

A. Comply with requirements in Section 076200 "Sheet Metal Flashing and Trim."

B. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required.

C. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

D. Set flashing on floors and roofs in solid coating of bituminous cement.

E. Secure flashing into sleeve and specialty clamping ring or device.

F. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Section 076200 "Sheet Metal Flashing and Trim."

G. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319

SECTION 221319.13 - SANITARY DRAINS

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. Floor drains.
2. Floor sinks.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 DRAIN ASSEMBLIES

A. Sanitary drains shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for plastic sanitary piping specialty components.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Commercial Enameling Company
b. Jay R. Smith Mfg. Co.
c. Josam Company
d. Tyler Pipe; a subsidiary of McWane Inc.
e. Zurn Industries, LLC

2. Standard: ASME A112.6.3.

B. Stainless-Steel Floor Drains, ASME A112.3.1:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Jay R. Smith Mfg. Co.
b. Josam Company
c. Kusel Equipment Co.
d. Scherping Systems, Inc.

e. Tyler Pipe; a subsidiary of McWane Inc.
f. Watts; a Watts Water Technologies company
g. Zurn Industries, LLC

2. Refer to Schedule on Drawings for capacity and characteristics.

C. Stainless-Steel Floor Drains, ASME A112.6.3:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Jay R. Smith Mfg. Co.
b. Josam Company
c. Kusel Equipment Co.
d. Scherping Systems, Inc.
e. Tyler Pipe; a subsidiary of McWane Inc.
f. Watts; a Watts Water Technologies company
g. Zurn Industries, LLC

2. Outlet: Bottom.
3. Top or Strainer Material: Stainless-steel.
4. Refer to Schedules on Drawings for capacity and characteristics.

2.3 FLOOR SINKS

A. Stainless-Steel Floor Sinks, ASME A112.6.7

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Commercial Enameling Company
b. Jay R. Smith Mfg. Co.
c. Josam Company
d. MIFAB, Inc.
e. Prier Products, Inc.
f. Tyler Pipe; a subsidiary of McWane Inc.
g. Watts; a Watts Water Technologies company
h. Zurn Industries, LLC

2. Standard: ASME A112.6.7.
3. Body Material: Stainless-steel.
4. Refer to Schedules on Drawings for capacity and characteristics.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

1. Position floor drains for easy access and maintenance.
2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
3. Set with grates depressed according to the following drainage area radii:

a. Radius, 30 Inches or Less: Equivalent to one percent (1%) slope, but not less than ¼-inch total depression.
b. Radius, 30 to 60 Inches: Equivalent to one percent (1%) slope.
c. Radius, 60 Inches or Larger: Equivalent to one percent (1%) slope, but not greater than 1-inch total depression.

4. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.

   a. Maintain integrity of waterproof membranes where penetrated.

5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

3.2 CONNECTIONS

A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements in Section 221319 "Sanitary Waste Piping Specialties" for miscellaneous sanitary drainage piping specialties.

C. Install piping adjacent to equipment to allow service and maintenance.

3.3 LABELING AND IDENTIFYING

A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319.13

SECTION 221323 - SANITARY WASTE INTERCEPTORS

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. Grease interceptors.
2. Precast-concrete manhole risers.

1.3 DEFINITIONS

A. FRP: Fiberglass-reinforced plastic.

B. PP: Polypropylene plastic.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of metal and plastic interceptor. Include materials of fabrication, dimensions, rated capacities, retention capacities, operating characteristics, size, and location of each pipe connection, furnished specialties, and accessories.

B. Shop Drawings: For each type and size of precast concrete interceptor indicated.

1. Include materials of construction, dimensions, rated capacities, retention capacities, location, and size of each pipe connection, furnished specialties, and accessories.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Interceptors, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Piping connections. Include size, location, and elevation of each.
2. Interface with underground structures and utility services.

1.6 FIELD CONDITIONS

A. Interruption of Existing Sewer Services: Do not interrupt services to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sewer services according to requirements indicated:

1. Notify Architect, Construction Manager, and Owner no fewer than seven (7) days in advance of proposed interruption of service.
2. Do not proceed with interruption of sewer services without written permission.

PART 2 - PRODUCTS

2.1 GREASE INTERCEPTORS

A. Precast-Concrete Grease Interceptors: Comply with ASTM C 913 and CT DEEP General Permit for the Discharge of Wastewater Associated with Food Service Establishments.

1. Include rubber-gasketed joints, vent connections, manholes, compartments or baffles, and piping or openings to retain grease and to permit wastewater flow.
2. Structural Design Loads:

    a. Light-Traffic Load: Comply with ASTM C 890, A-8.
    b. Medium-Traffic Load: Comply with ASTM C 890, A-12.
    c. Heavy-Traffic Load: Comply with ASTM C 890, A-16.
    d. Walkway Load: Comply with ASTM C 890, A-03.

3. Resilient Pipe Connectors: ASTM C 923, cast or fitted into interceptor walls, for each pipe connection.
4. Manhole Frames and Covers: Ferrous; 24-inch ID by 7- to 9-inch riser with 4-inch minimum-width flange and 26-inch diameter cover.

    a. Ductile Iron: ASTM A 536, Grade 60-40-18, unless otherwise indicated.
    b. Include indented top design with lettering cast into cover, using wording equivalent to "GREASE INTERCEPTOR”.

5. Capacities and Characteristics:

    a. See Drawings for details.

2.2 PRECAST-CONCRETE MANHOLE RISERS

A. Precast Concrete Manhole Risers: ASTM C 478, with rubber-gasket joints.

1. Structural Design Loads:

    a. Light-Traffic Load: Comply with ASTM C 890, A-8.
    b. Medium-Traffic Load: Comply with ASTM C 890, A-12.
    c. Heavy-Traffic Load: Comply with ASTM C 890, A-16.
    d. Walkway Load: Comply with ASTM C 890, A-03.

2. Length: From top of underground concrete structure to grade.
3. Riser Sections: 3-inch minimum thickness and 36-inch diameter.
4. Top Section: Eccentric cone unless otherwise indicated. Include top of cone to match grade ring size.
5. Gaskets: ASTM C 443, rubber.

B. Manhole Frames and Covers: Ferrous; 24-inch ID by 7- to 9-inch riser with 4-inch minimum-width flange and 26-inch diameter cover.

1. Ductile Iron: ASTM A 536, Grade 60-40-18, unless otherwise indicated.
2. Gray Iron: ASTM A 48, Class 35, unless otherwise indicated.
3. Include indented top design with lettering cast into cover, using wording equivalent to "GREASE INTERCEPTOR”.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 INSTALLATION

A. Install precast concrete interceptors according to ASTM C 891.

B. Set interceptors level and plumb.

C. Install manhole risers from top of underground concrete interceptors to manholes and gratings at finished grade.

D. Set tops of manhole frames and covers flush with finished surface in pavements.

E. Set tops of grating frames and grates flush with finished surface.

F. Install grease interceptors, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing.

1. Above-Floor Installation: Set unit with bottom resting on floor unless otherwise indicated.
2. Flush with Floor Installation: Set unit and extension, if required, with cover flush with finished floor.
3. Recessed Floor Installation: Set unit in receiver housing having bottom or cradle supports, with receiver housing cover flush with finished floor.
4. Install cleanout immediately downstream from interceptors not having integral cleanout on outlet.

G. Install solids interceptors with cleanout immediately downstream from interceptors that do not have integral cleanout on outlet.

1. Install trap on interceptors that do not have integral trap and are connected to sanitary drainage and vent systems.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Make piping connections between interceptors and piping systems.

3.4 IDENTIFICATION

A. Identification materials and installation are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

1. Arrange for installation of green warning tapes directly over piping and at outside edges of underground interceptors.
2. Use warning tapes or detectable warning tape over ferrous piping.
3. Use detectable warning tape over nonferrous piping and over edges of underground structures.

B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Grease interceptors.

3.5 PROTECTION

A. Protect sanitary waste interceptors from damage during construction period.

B. Repair damage to adjacent materials caused by sanitary waste interceptor installation.

END OF SECTION 221323

SECTION 223300 - ELECTRIC WATER HEATERS

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. Fully integrated heat pump water heaters.
2. Water heater accessories.

1.3 ACTION SUBMITTALS

A. Product Data: For each type and size of electric heat pump commercial water heaters indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For commercial domestic-water heaters, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Product Certificates: For each type of tank type, electric, heat pump commercial water heaters, from manufacturer.

C. Heat Pump Commercial Water Heaters Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

D. Source quality-control reports.

E. Field quality-control reports.

F. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric, heat pump commercial water heaters to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

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

B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

C. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects."

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric heat pump commercial water heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including storage tank and supports.
b. Faulty operation of controls.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Periods: From date of Substantial Completion.

a. Electric, Heat Pump Commercial Water Heaters: One (1) year.

PART 2 - PRODUCTS

2.1 ELECTRIC, HEAT PUMP COMMERCIAL WATER HEATERS

A. Thermostatic Control, Electric, Heat Pump Commercial Water Heaters:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. AO Smith
b. Lochivar
c. PVI, Inc.

2. Standard: UL 499 for Electric, Heat Pump Commercial Water Heaters heating appliance.
3. National Sanitation Foundation NSF-5 requirements.

4. Meets or exceeds the efficiency and standby loss requirements of the U.S. Department of Energy and current edition of ASHRAE 118.1.
5. The heat pump water heater shall be capable of operating in Efficiency, Hybrid, or Electric only modes.
6. The water heater shall have an LCD display with built-in diagnostic and troubleshooting information.
7. All internal surfaces of the tank exposed to water shall be glass-lined with an alkaline borosilicate composition that has been fused to steel by firing at a temperature range of 1400°F to 1600°F.
8. Internal power circuit fusing shall be provided.
9. Construction: Copper piping or tubing complying with NSF 61 Annex G barrier materials for potable water, with storage capacity.

    a. Connections: ASME B1.20.1 pipe thread.
    b. Pressure Rating: 150 psig.
    c. Heating Element: Resistance heating system.
    d. Temperature Control: Thermostat.
    e. Safety Control: High-temperature-limit cutoff device or system.
    f. Jacket: Aluminum or steel with enameled finish or plastic.

10. For Capacity and Characteristics: Refer to Schedules on Drawings.

2.2 HEAT PUMP WATER HEATERS ACCESSORIES

A. Electric Heat Pump Commercial Water Heaters Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting heat pump commercial water heater and water.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect domestic-water heaters specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 HEAT PUMP WATER HEATER INSTALLATION

A. Heat Pump Commercial Water Heater Mounting: Install electric, tank type, commercial water heater on floor on concrete housekeeping pad.

1. Maintain manufacturer's recommended clearances.
2. Arrange units so controls and devices that require servicing are accessible.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Anchor domestic-water heaters to substrate.

B. Install commercial water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

1. Install shutoff valves on domestic-water-supply piping to commercial water heaters and on hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523.12 "Ball Valves for Plumbing Piping."

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to commercial water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of commercial water heaters.

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Electric heat pump commercial water heater will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

C. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heat pump commercial water heater.

END OF SECTION 223300

SECTION 224213.13 - COMMERCIAL WATER CLOSETS

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. Water closets.
2. Flushometer valves.
3. Toilet seats.
4. Supports.

1.3 DEFINITIONS

A. Effective Flush Volume: Average of two reduced flushes and one full flush per fixture.

B. Remote Water Closet: Located more than 30 feet from other drain line connections or fixture and where less than one and one-half (1.5) drainage fixture units are upstream of the drain line connection.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water closets.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For flushometer valves and electronic sensors to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that are packaged with protective covering for storage and identified with labels describing contents.

1. Flushometer-Valve Repair Kits: Equal to ten percent (10%) of amount of each type installed, but no fewer than six (6) of each type.

PART 2 - PRODUCTS

2.1 WALL-MOUNTED WATER CLOSETS

A. Water Closets: Wall mounted, back spud, accessible.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. American Standard America
b. Sloan Valve Company
c. Kohler Co.
d. Zurn Industries, LLC

2. Bowl:

a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
b. Material: Vitreous china.
c. Type: Siphon jet.
d. Style: Flushometer valve.
e. Height: Standard.
f. Rim Contour: Elongated.
g. Water Consumption: 1.6 gal. per flush.
h. Spud Size and Location: NPS 1-1/2; back.

3. Support: Water closet carrier
4. Water-Closet Mounting Height: Standard and Handicapped/elderly according to ICC A117.1.

2.2 FLUSHOMETER VALVES

A. Hard-Wired, Solenoid-Actuator, Piston Flushometer Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Gerber Plumbing Fixtures LLC
b. Moen Incorporated
c. Sloan Valve Company
d. TOTO USA, INC.
e. Zurn Industries, LLC

2. Standard: ASSE 1037.
3. Minimum Pressure Rating: 125 psig.
4. Features: Include integral check stop and backflow-prevention device.
5. Material: Brass body with corrosion-resistant components.
6. Exposed Flushometer-Valve Finish: Chrome plated.
7. Panel Finish: Chrome plated or stainless-steel.
8. Style: Exposed.
9. Actuator: Solenoid complying with UL 1951, and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
10. Trip Mechanism: Hard-wired electronic sensor complying with UL 1951, and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

11. Consumption: 1.6 gal. per flush.

2.3 TOILET SEATS

A. Toilet Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. American Standard America
b. Bemis Manufacturing Company
c. Centoco Manufacturing Corporation
d. Church Seats; Bemis Manufacturing Company
e. Kohler Co.
f. Olsonite Seat Co.
g. TOTO USA, INC.
h. Zurn Industries, LLC

2. Standard: IAPMO/ANSI Z124.5.
3. Material: Plastic.
4. Type: Commercial (heavy duty).
5. Shape: Elongated rim, open front.
6. Hinge: Self-sustaining, check.
7. Hinge Material: Noncorroding metal.
8. Seat Cover: Not required.
9. Color: White.

2.4 SUPPORTS

A. Water Closet Carrier:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Jay R. Smith
b. Josam
c. Zurn Industries, LLC

2. Standard: ASME A112.6.1M.
3. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before water-closet installation.

B. Examine walls and floors for suitable conditions where water closets will be installed.

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

3.2 INSTALLATION

A. Water-Closet Installation:

1. Install level and plumb according to roughing-in drawings.
2. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.

B. Support Installation:

1. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
2. Use carrier supports with waste-fitting assembly and seal.
3. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.

C. Flushometer-Valve Installation:

1. Install flushometer-valve, water-supply fitting on each supply to each water closet.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
4. Install actuators in locations that are easy for people with disabilities to reach.
5. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

D. Install toilet seats on water closets.

E. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

F. Joint Sealing:

1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to water-closet color.
3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Where installing piping adjacent to water closets, allow space for service and maintenance.

3.4 ADJUSTING

A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.

B. Adjust water pressure at flushometer valves to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed water closets and fittings.

C. Do not allow use of water closets for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.13

SECTION 224216.13 - COMMERCIAL LAVATORIES

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. Lavatories.
2. Faucets.
3. Supports.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for lavatories.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include diagrams for power, signal, and control wiring of automatic faucets.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lavatories and faucets to include in operation and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Servicing and adjustments of automatic faucets.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Faucet Washers and O-Rings: Equal to ten percent (10%) of amount of each type and size installed.
2. Faucet Cartridges and O-Rings: Equal to five percent (5) of amount of each type and size installed.

PART 2 - PRODUCTS

2.1 VITREOUS-CHINA, WALL-MOUNTED LAVATORIES

A. Lavatory: Vitreous china, wall mounted.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. American Standard America
b. Sloan Valve Company
c. Zurn Industries, LLC

2. Fixture:

a. Standard: ASME A112.19.2/CSA B45.1.
b. Type: For wall hanging.

3. Refer to Schedules on Drawings for capacity and characteristics.

2.2 SOLID-BRASS, AUTOMATICALLY OPERATED LAVATORY FAUCETS

A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.

B. Lavatory Faucets: Automatic-type, hard-wired, electronic-sensor-operated, mixing, solid-brass valve.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. American Standard America
b. Bradley Corporation
c. Sloan Valve Company
d. Zurn Industries, LLC

2. Standards: ASME A112.18.1/CSA B125.1 and UL 1951.
3. 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.
4. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
5. Refer to Schedules on Drawings for capacity and characteristics.

2.3 SUPPORTS

A. Type II Lavatory Carrier:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Jay R. Smith Mfg. Co.
b. Josam Company
c. MIFAB, Inc.
d. Wade Drains

e. Watts; a Watts Water Technologies company
f. Zurn Industries, LLC

2. Standard: ASME A112.6.1M.

B. Type III Lavatory Carrier:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Jay R. Smith Mfg. Co.
b. Josam Company
c. MIFAB, Inc.
d. Wade Drains
e. Watts; a Watts Water Technologies company
f. Zurn Industries, LLC

2. Standard: ASME A112.6.1M.

2.4 SUPPLY FITTINGS

A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.

B. Standard: ASME A112.18.1/CSA B125.1.

C. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless-steel wall flange.

D. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

E. Operation: Loose key.

F. Risers:

1. NPS 3/8.
2. Chrome-plated, rigid-copper-pipe and brass straight or offset tailpieces riser.

2.5 WASTE FITTINGS

A. Standard: ASME A112.18.2/CSA B125.2.

B. Drain: Grid type with NPS 1-1/4 offset and straight tailpiece.

C. Trap:

1. Size: NPS 1-1/2 by NPS 1-1/4.
2. Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch-thick brass tube to wall; and chrome-plated, brass or steel wall flange.

2.6 SUPPORTS

A. Type II Lavatory Carrier:

1. Standard: ASME A112.6.1M.

B. Type III Lavatory Carrier:

1. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before lavatory installation.

B. Examine counters and walls for suitable conditions where lavatories will be installed.

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

3.2 INSTALLATION

A. Install lavatories level and plumb according to roughing-in drawings.

B. Install supports, affixed to building substrate, for wall-mounted lavatories.

C. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, according to ICC/ANSI A117.1.

D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

E. Seal joints between lavatories, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.3 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

A. After completing installation of lavatories, inspect and repair damaged finishes.

B. Clean lavatories, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed lavatories and fittings.

D. Do not allow use of lavatories for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.13

SECTION 224216.16 - COMMERCIAL SINKS

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. Service basins.
2. Kitchen/Utility sinks.
3. Sink faucets.
4. Supply fittings.
5. Waste fittings.
6. Supports.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for sinks.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For sinks to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Faucet Washers and O-Rings: Equal to ten percent (10%) of amount of each type and size installed.
2. Faucet Cartridges and O-Rings: Equal to five percent (5%) of amount of each type and size installed.

PART 2 - PRODUCTS

2.1 SERVICE BASINS

A. Service Basins: Terrazzo, floor mounted.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Acorn Engineering Company
    b. Crane Plumbing, LLC
    c. Florestone Products Co., Inc.
    d. Stern-Williams Co., Inc.

2. Fixture:

    a. Standard: IAPMO PS 99.

3. Refer to Schedules on Drawings for characteristics and capacity.

2.2 KITCHEN/UTILITY SINKS

A. Kitchen/Utility Sinks – Stainless-Steel:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Advance Tabco
    b. Eagle Group
    c. Elkay Manufacturing Co.
    d. Just Manufacturing

2. Source Limitations: Obtain sinks from single source from single manufacturer.
3. Fixture:

    a. Standard: ASME A112.19.3/CSA B45.4.
    b. Type: Stainless-steel, self-rimming, sound-deadened unit
    c. Material: 18-gauge, Type 304 stainless-steel.

4. Refer to Schedules on Drawings for characteristics and capacity.

2.3 SINK FAUCETS

A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for faucet-spout materials that will be in contact with potable water.

B. Sink Faucets: Manual type, single-control.

1. Commercial, Solid-Brass Faucets.

    a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

        1) American Standard America
        2) Elkay Manufacturing Co.
        3) Just Manufacturing
        4) Sloan Valve Company
        5) Zurn Industries, LLC

2. Standard: ASME A112.18.1/CSA B125.1.

3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
4. Refer to Schedules on Drawings for characteristics and capacity.

2.4 SUPPORTS

A. Type II Sink Carrier:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Jay R. Smith Mfg. Co.
b. Josam Company
c. MIFAB, Inc.
d. Wade Drains
e. Watts; a Watts Water Technologies company
f. Zurn Industries, LLC

2. Standard: ASME A112.6.1M.

2.5 SUPPLY FITTINGS

A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.

B. Standard: ASME A112.18.1/CSA B125.1.

C. Supply Piping: Chrome-plated brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated brass or stainless-steel wall flange.

D. Supply Stops: Chrome-plated brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

E. Operation: Loose key.

F. Risers:

1. NPS 3/8.
2. ASME A112.18.6, braided or corrugated stainless-steel flexible hose.

2.6 WASTE FITTINGS

A. Standard: ASME A112.18.2/CSA B125.2.

B. Drain: Grid type with NPS 1-1/2 offset and straight tailpiece.

C. Trap:

1. Size: NPS 1-1/2.
2. Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch-thick brass tube to wall; and chrome-plated brass or steel wall flange.

2.7 GROUT

A. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

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

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

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before sink installation.

B. Examine walls, floors, and counters for suitable conditions where sinks will be installed.

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

3.2 INSTALLATION

A. Install sinks level and plumb according to roughing-in drawings.

B. Install supports, affixed to building substrate, for wall-hung sinks.

C. Install accessible wall-mounted sinks at handicapped/elderly mounting height according to ICC/ANSI A117.1.

D. Set floor-mounted sinks in leveling bed of cement grout.

E. Install water-supply piping with stop on each supply to each sink faucet.

1. Exception: Use ball or gate valves if supply stops are not specified with sink. Comply with valve requirements specified in Sections 220523.12 "Ball Valves for Plumbing Piping" and 220523.15 "Gate Valves for Plumbing Piping."
2. Install stops in locations where they can be easily reached for operation.

F. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

G. Seal joints between sinks and counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

H. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.3 CONNECTIONS

A. Connect sinks with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Operate and adjust sinks and controls. Replace damaged and malfunctioning sinks, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

A. After completing installation of sinks, inspect and repair damaged finishes.

B. Clean sinks, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed sinks and fittings.

D. Do not allow use of sinks for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.16

SECTION 224716 - PRESSURE WATER COOLERS

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 pressure water coolers and related components.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of pressure water cooler.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For pressure water coolers to include in maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filter Cartridges: Equal to ten percent (10%) of quantity installed for each type and size indicated, but no fewer than one (1) of each.

PART 2 - PRODUCTS

2.1 PRESSURE WATER COOLERS WITH BOTTLE FILLER STATION

A. Pressure Water Coolers: Wall mounted, standard and wheelchair accessible.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Elkay Manufacturing Co.
b. Halsey Taylor
c. Haws Corporation

2. Cabinet: Bi-level with two (2) attached cabinets and with a bi-level skirt kit, all stainless-steel.
3. Bubbler: One (1), with adjustable stream regulator, located on each cabinet deck.

4. Bottle Filler Station: One (1), touch less activation, LED filter monitor, LED bottle counter, located on lower cabinet deck.
5. Control: Push button/bar.
6. Drain: Grid with NPS 1-1/4 tailpiece.
7. Supply: NPS 3/8 with shutoff valve.
8. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 brass P-trap.
9. Filter: One (1) or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
10. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.

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

11. Capacities and Characteristics:

    a. Refer to Schedules on Drawings.

12. Water Cooler Mounting Height: Standard & Handicapped/elderly according to ICC A117.1.

2.2 SUPPORTS

A. Type I Water Cooler Carrier:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Jay R. Smith Mfg. Co.
    b. Josam Company
    c. MIFAB, Inc.
    d. Wade Drains
    e. Watts; a Watts Water Technologies company
    f. Zurn Industries, LLC

2. Standard: ASME A112.6.1M.

B. Type II Water Cooler Carrier:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Jay R. Smith Mfg. Co.
    b. Josam Company
    c. MIFAB, Inc.
    d. Wade Drains
    e. Watts; a Watts Water Technologies company
    f. Zurn Industries, LLC

2. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.

B. Examine walls and floors for suitable conditions where fixtures will be installed.

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

3.2 INSTALLATION

A. Install fixtures level and plumb according to roughing-in drawings. For fixtures indicated for children, install at height required by authorities having jurisdiction.

B. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball or gate valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Sections 220523.12 "Ball Valves for Plumbing Piping" and 220523.15 "Gate Valves for Plumbing Piping."

C. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.

D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

E. Seal joints between fixtures and walls using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Install ball or gate shutoff valve on water supply to each fixture. Install valve upstream from filter for water cooler. Comply with valve requirements specified in Sections 220523.12 "Ball Valves for Plumbing Piping" and 220523.15 "Gate Valves for Plumbing Piping."

D. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

B. Adjust pressure water-cooler temperature settings.

3.5 CLEANING

A. After installing fixture, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

C. Provide protective covering for installed fixtures.

D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224716

SECTION 230000 - BASIC MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Basic Mechanical Requirements specifically applicable to Division 23 Sections in addition to Division 01 General Requirements.

1.2 INTENT

A. It is the intention of the Specifications and Drawings to call for finished work, tested and ready for operation. All materials, equipment and apparatus shall be new and of first-class quality.

B. Any apparatus, appliance, material or work not shown on Drawings, but mentioned in the Specifications, or vice versa, or any incidental accessories or minor details not shown, but necessary to make the work complete and perfect in all respects and ready for operation, even if not particularly specified, shall be provided by the Contractor without additional expense to the Owner.

C. With submission of bid, the Contractor shall give notice to the Engineer of any materials apparatus or omissions believed to be in violation of laws, ordinances, rules or regulations or authorities having jurisdiction. In the absence of such written notice, it is mutually agreed that the Contractor shall include the cost of providing all systems in accordance with applicable regulations without extra compensation.

1.3 SUBMITTALS

A. Submit under provisions of Division 01 Sections.

B. Include products as required by individual Sections.

C. Submit Shop Drawings and Product Data grouped to include complete submittals of related systems, products, and accessories in a single submittal.

D. Mark dimensions and values in units to match those specified.

E. Submit plan indicating measures being taken to maintain indoor air quality of occupied portion of building during construction.

1.4 DRAWINGS AND COORDINATION

A. Drawings are schematic in nature and do not indicate every item, piece of equipment and detail. Provide complete, operating systems.

B. Install work as closely as possible to layouts shown on drawings. Modify work as necessary to meet job conditions and to clear other equipment. Consult Architect before making changes which affect the function or appearance of systems.

C. Dimensions, elevations, and locations are shown approximately. Verify dimensions in field.

D. Architect reserves the right to order changes in layout of such items as piping, ducts, and equipment if such changes do not substantially affect costs and if effected items have not been fabricated or installed.

E. In some cases, drawings are based on products of one (1) or several manufacturers, as listed on Contract Documents. Contractor shall be responsible for modifications made necessary by substitution of products of other manufacturers. Modifications may be required in electrical distribution materials and components, structural supports, concrete pads, gas piping, breeching and chimneys, etc.

F. Do not install part of a system until all critical components of the system and related systems have been approved. Coordinate parts of systems.

G. Coordinate work with work specified in other Sections. Relocate work if required for proper installation and functioning of other systems.

H. Install products in accordance with manufacturer's instructions. Notify Architect if Contract Documents conflict with manufacturer's instructions. Comply with Architect's interpretations.

I. Provide brackets, supports, anchors and frames required for installation of work specified in this division. Such metal work shall conform to the requirements of Section 055000 “Metal Fabrications”.

J. Where Contract Documents provide conflicting information, Contractor shall be responsible for design having highest cost.

1.5 PROJECT RECORD DRAWINGS

A. Prepare project Record Drawings of mechanical systems in conformance with the requirements of the General Conditions and Division 01 Sections.

1.6 INDOOR AIR QUALITY

A. Provide measures to maintain minimum standard for indoor air quality in accordance with SMACNA guidelines, by preventing air contaminated by demolition and construction activities from being transferred to occupied portions of building when work includes renovation, addition or alteration to building occupied during demolition/construction.

B. Measures shall include but not be limited to the following:

1. Air filtration.
2. Temporarily sealing ductwork, air inlets and outlets and ventilation openings to prevent transfer of contaminated air.
3. Installation of bypass ducts or openings and additional temporary system modifications as required to prevent cross contamination, and to maintain proper system operation during construction.

C. Submit plan of cross contamination control measures in accordance with SMACNA guidelines prior to beginning construction.

1.7 PRELIMINARY OPERATION

A. Operate mechanical systems with required supervision for at least two (2) full days prior to substantial completion. Make necessary adjustments and check proper operation.

1.8 TESTS PRIOR TO SUBSTANTIAL COMPLETION

A. Tests shall be attended by representatives of mechanical subcontractors, equipped with instruments required to demonstrate proper functioning of systems, as specified. Demonstrate the following:

1. Equipment installed and operating in accordance with the manufacturer's specifications and instructions and with these specifications.
2. Safety and temperature controls operating as specified.
3. Systems properly flushed, cleaned and free of contaminants.
4. Systems properly balanced.
5. Motors equipped with proper overload protection and not operating under overload. Obtain ammeter readings.
6. Instruments recording properly.
7. Submit report listing system tested, date, results, and description of fault corrections, if any.

1.9 WARRANTY

A. Submit written warranty of warranties covering work specified in Division 23.

B. Warranty will commence as the construction phases are completed.

C. Warranty period shall be one (1) year after the equipment/system has been put into permanent operating mode, equipment/system and components have been commissioned by the Commissioning Agent and accepted, and the operating and maintenance manuals have been submitted and approved.

D. Owner is to receive full use of equipment for period of warranty.

1.10 OPERATING AND MAINTENANCE MANUALS

A. Submit Operating and Maintenance manuals in accordance with this Section and Division 01 Sections.

B. Include operating and maintenance instructions for equipment where applicable.

C. List replacement parts and order procedure.

D. Include lubrication instructions and schedule, with types of lubricant to be used.

E. Instruct Owner's personnel in use of equipment specified in this Division.

1.11 REGULATORY REQUIREMENTS

A. Conform to applicable provisions of the 2022 Connecticut Basic Building Code which include the following:

1. 2021 International Building Code
2. 2021 International Mechanical Code

B. Amendments, alterations, deletions, and addition of certain provisions to the above as indicated in Connecticut Supplement.

C. New construction and renovation work will also conform to applicable provisions of the Connecticut Public Health Code.

D. Indoor air quality during construction will be maintained in accordance with SMACNA IAQ Guidelines for Occupied Buildings under Construction.

E. New construction and renovation work will also conform to applicable provisions of the Connecticut Fire Safety Code which include the following:

1. Amendments, alterations, deletions, and addition of certain provisions to the above as indicated in the Connecticut Supplement.

F. Work of this project shall be barrier free and will conform to the Americans with Disabilities Act (ADA), ICC/ANSI 117.1, 2010 and Uniform Federal Accessibility Standards (UFAS).

G. New construction and renovations work will comply with the requirements of the 2021 International Energy Conservation Code for energy efficiency.

H. Conform to applicable Town of Montville requirements.

I. Obtain and pay for permits and inspections from authorities having jurisdiction.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 230000

SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

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. Sleeves.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Galvanized-Steel Wall Pipes: ASTM A 53, Schedule 40, with plain ends and welded steel collar; zinc coated.

B. Galvanized-Steel-Pipe Sleeves: ASTM A 53, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

C. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

D. PVC Pipe Sleeves: ASTM D 1785, Schedule 40.

E. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

2.2 SLEEVE-SEAL SYSTEMS

A. Manufacturer:

1. Metraflex; **Metraseal System**
2. GPT EnPro Industries Company; **Link-Seal**
3. Calpico Inc.; **Pipe Linx**

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

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
2. Pressure Plates: Stainless-steel.
3. Connecting Bolts and Nuts: Stainless-steel of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Manufacturer:

1. Metraflex; **Metraseal System**
2. GPT EnPro Industries Company; **Link-Seal**
3. Calpico Inc.; **Pipe Linx**

B. Description:

1. Manufactured plastic, sleeve-type, waterstop assembly, made for imbedding in concrete slab or wall.
2. Plastic or rubber waterstop collar with center opening to match piping OD.

2.4 GROUT

A. Description: Non-shrink, recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

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

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

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

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

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

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

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

3. Using grout, seal space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide ¼-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

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

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

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings as new walls and slabs are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal space around outside of sleeve-seal fittings.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Walls above Grade:

a. Piping Smaller Than NPS 6 (DN 150): Galvanized-steel-pipe sleeves with sleeve-seal fittings.

2. Interior Partitions:

a. Piping Smaller Than NPS 6 (DN 150): Galvanized-steel-pipe sleeves.

END OF SECTION 230517

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

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. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Equipment supports.

B. Related Sections:

1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
3. Division 23 Section "Vibration Controls for HVAC Piping and Equipment" for vibration isolation devices.
4. Division 23 Section Metal Ducts for duct hangers and supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

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

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

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

3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.5 ACTION SUBMITTALS

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

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Pipe stands.
4. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

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

B. Copper Pipe Hangers:

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

2.2 TRAPEZE PIPE HANGERS

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

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flex-Strut Inc.
   b. Unistrut Corporation; Tyco International, Ltd.
   c. Wesanco, Inc.
   d. GS Metals Corp.

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

B. Non-MFMA Manufacturer Metal Framing Systems:

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

   a. Anvil International; a subsidiary of Mueller Water Products Inc.
   b. Empire Industries, Inc.
   c. ERICO International Corporation.

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

2.4 THERMAL-HANGER SHIELD INSERTS

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

1. Carpenter & Paterson, Inc.
2. Clement Support Services.
3. ERICO International Corporation.
4. National Pipe Hanger Corporation.
5. PHS Industries, Inc.

B. Insulation-Insert Material for Cold Piping: ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength.

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

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

F. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

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

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

2.6 PIPE STANDS

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

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

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

D. High-Type, Multiple-Pipe Stand:

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

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

2.7 EQUIPMENT SUPPORTS

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

2.8 MISCELLANEOUS MATERIALS

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

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

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

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

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

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

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

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

E. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.

2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Division 07 Section "Roof Accessories" for curbs.

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

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

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

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

K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

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

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

N. Insulated Piping:

1. Attach clamps and spacers to piping.

   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

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

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

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

   a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
   b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.

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

3.2 PIPE HANGERS AND SUPPORT SPACING

A. Support horizontal steel and copper as follows:
   1. ½” to 1 ¼” Pipe Size : 6’-0” maximum hanger spacing.

2. 1 ½" to 2" Pipe Size : 10'-0" maximum hanger spacing.
3. 2 ½" to 3" Pipe Size : 10'-0" maximum hanger spacing.
4. 4" to " Pipe Size : 10'-0" maximum hanger spacing.

3.3 EQUIPMENT SUPPORTS

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

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

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

3.4 METAL FABRICATIONS

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

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

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

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

3.5 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

3.6 PAINTING

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

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections.

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

3.7 HANGER AND SUPPORT SCHEDULE

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

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

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

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

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

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

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

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

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

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C),pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).

12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

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

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.

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

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.

2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb (340 kg).
    b. Medium (MSS Type 32): 1500 lb (680 kg).
    c. Heavy (MSS Type 33): 3000 lb (1360 kg).

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

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

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

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

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.

8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

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

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

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

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

END OF SECTION 230529

SECTION 230548.13 - VIBRATION CONTROLS FOR HVAC

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. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Restrained spring isolators.
5. Elastomeric hangers.
6. Vibration isolation equipment support rails.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
3. Vibration Restraint Details: Detailed submittal drawings of vibration restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors. Include ratings for loads.

C. Delegated-Design Submittal: For each vibration isolation device.

1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

1.5 COORDINATION

A. Coordinate with vibration isolation restraint manufacturer and the structural engineer of record to locate and size structural supports underneath vibration isolated restrained equipment.

1.6 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS: Subject to compliance with requirements, provide products by one (1) of the following:

1. Mason Industries
2. Novia: A Division of C&P
3. Vibration Isolation

2.2 ELASTOMERIC ISOLATION PADS

A. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.

B. Size: Factory or field cut to match requirements of supported equipment.

C. Verify availability of various pad materials and their properties with manufacturers.

D. Pad Material: Oil and water resistant with elastomeric properties.

E. Surface Pattern: **Waffle** pattern.

F. Load-bearing metal plates adhered to pads.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Mounting Plates:
1. Top Plate: Encapsulated steel load transfer top plates, factory drilled **with threaded studs or bolts**.
2. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

B. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Description: All-directional isolator with restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
1. Housing: Cast-ductile iron or welded steel.

2. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5 RESTRAINED SPRING ISOLATORS

A. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

B. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside.

C. Top plate with threaded mounting holes.

D. Internal leveling bolt that acts as blocking during installation.

E. Restraint: Limit stop as required for equipment and authorities having jurisdiction.

F. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

G. Minimum Additional Travel: 50 percent of the required deflection at rated load.

H. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

I. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.6 ELASTOMERIC HANGERS

A. Double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

2.7 SPRING HANGERS

A. Frame: Steel, fabricated for connection to threaded hangers rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

B. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

C. Minimum Additional Travel: 50 percent of the required deflection at rated load.

D. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

E. Minimum deflection as indicated on Drawings.

F. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

G. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.

H. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.

I. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.8 VIBRATION ISOLATION EQUIPMENT SUPPORT RAILS

A. Steel Rails: Factory-fabricated, welded, structural-steel rails.
   1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor.
   2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Rails shall have shape to accommodate supported equipment.
   3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

B. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.
   1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
   2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases shall have shape to accommodate supported equipment.
   3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

2.9 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

   1. Powder coating on springs and housings.
   2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
   3. Baked enamel or powder coat for metal components on isolators for interior use.
   4. Color-code or otherwise mark vibration isolation and seismic- and wind-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 VIBRATION CONTROL DEVICE INSTALLATION

A. Provide vibration control devices for systems and equipment where indicated in Drawings, where Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole.

D. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

E. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

3.3 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT SUPPORT RAILS

A. Coordinate dimensions of equipment with requirements of isolated equipment specified. Install in accordance with manufacturer’s requirements.

END OF SECTION 230548.13

SECTION 230553 - IDENTIFICATION FOR HVAC

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. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.
5. Valve tags.
6. Warning tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Brady Corporation
    b. Brimar Industries, Inc.
    c. Carlton Industries, LP
    d. Seton Identification Products
2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware. Material shall be rated for indoor and outdoor use.
3. Letter Color: White.
4. Background Color: Black.

5. Minimum Label Size: Length and width vary for required label content, but not less than 2½-by-¾-inch.
6. Minimum Letter Size: ¼-inch for name of units if viewing distance is less than 24 inches, ½-inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8½-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Brady Corporation
2. Brimar Industries, Inc.
3. Carlton Industries, LP
4. Champion America
5. Craftmark Pipe Markers
6. emedco
7. LEM Products Inc.
8. Marking Sevices Inc.
9. National Marker Company
10. Seton Identification Products
11. Stranco, Inc.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch-thick, and having predrilled holes for attachment hardware.

C. Letter Color: Black.

D. Background Color: Yellow.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

F. Minimum Label Size: Length and width vary for required label content, but not less than 2½-by-¾-inch.

G. Minimum Letter Size: ¼-inch for name of units if viewing distance is less than 24 inches, ½-inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

H. Fasteners: Stainless-steel rivets or self-tapping screws.

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

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

2.3 PIPE LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
2. Brady Corporation
3. Carlton Industries, LP
4. Champion America
5. Craftmark Pipe Markers
6. Brimar Industries, Inc.
7. LEM Products Inc.
8. Marking Sevices Inc.
9. National Marker Company
10. Seton Identification Products

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1½ inches high.

2.4 DUCT LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Brady Corporation
2. Brimar Industries, Inc.
3. Carlton Industries, LP
4. Champion America
5. Craftmark Pipe Markers
6. emedco
7. LEM Products Inc.
8. Marking Sevices Inc.
9. National Marker Company
10. Seton Identification Products

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch-thick, and having predrilled holes for attachment hardware.

C. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

D. Minimum Label Size: Length and width vary for required label content, but not less than 2½-by-¾-inch.

E. Minimum Letter Size: ¼-inch for name of units if viewing distance is less than 24 inches, ½-inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

F. Fasteners: Stainless-steel rivets or self-tapping screws.

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

H. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

2.5 VALVE TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Brady Corporation
2. Brimar Industries, Inc.
3. Carlton Industries, LP
4. Champion America
5. Craftmark Pipe Markers
6. Emedco
7. LEM Products Inc.
8. Marking Sevices Inc.
9. National Marker Company
10. Seton Identification Products

B. Valve Tags: Stamped or engraved with ¼-inch letters for piping system abbreviation and ½-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link chain.

C. Valve Schedules: For each piping system, on 8½-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

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

D. Valve Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Included mounting screws.

1. Frame: Extruded Aluminum.
2. Glazing: ASTM C 1036, Type I, Class I, Glazing Quality B, 2.5-mm, single thickness glass.

2.6 ACCESS PANEL AND DOOR MARKERS

A. Access Panel and Door Markers: 1/16-inch-thick, engraved laminated plastic with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment. Fasteners: Self-tapping, stainless steel screws or contact type, permanent adhesive.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 GENERAL INSTALLATION REQUIREMENTS

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

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

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

3.3 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Section 099123 "Interior Painting."

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

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 20 feet along each run. Reduce intervals to 15 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

D. Pipe Label Color Schedule:

1. Heating Water Piping: Black letters on a yellow background.
2. Refrigerant Piping: White letters on a safety-green background.
3. Make-Up Water Piping: White letters on a safety-green background.

3.5 DUCT LABEL INSTALLATION

A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.6 VALVE-TAG INSTALLATION

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

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

a. Hot Water: 2 inches round.
b. Refrigerant: 2 inches, round.
c. Gas: 2 inches, round.

2. Valve Tag Color:

a. Toxic and Corrosive Fluids: Black letters on a safety-orange background.
b. Flammable Fluids: Black letters on a safety-yellow background.
c. Combustible Fluids: White letters on a safety-brown background.
d. Potable and Other Water: White letters on a safety-green background.

3.7 WARNING-SIGNS AND LABELS INSTALLATION

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

3.8 AUTOMATIC TEMPERATURE CONTROLS IDENTIFICATION

A. ATC Controllers Installed Above T-Bar Ceiling: Label T-bar grid with ATC identifiers. Use label maker with peel and stick labels, yellow background, and black lettering.

3.9 TERMINAL UNITS

A. Mark all terminal units so that the markings can be easily read from the most likely viewing position (e.g., through the ceiling below, etc.).

B. Terminal Units Installed Above T-Bar Ceiling: Label T-bar with terminal unit identifier as shown on the Drawings. Use label maker with peel and stick labels, blue background, and black lettering.

END OF SECTION 230553

SECTION 230593 – TESTING, ADJUSTING, AND BALANCING FOR HVAC

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. Balancing Air Systems:
   a. Constant-volume air systems.

2. Testing, Adjusting, and Balancing Equipment:
   a. Air handling unit
   b. Variable refrigerant flow system
   c. Energy Recovery Ventilator

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An entity engaged to perform TAB Work.

1.4 ACTION SUBMITTAL

A. TAB Report: Documentation of work performed for ASHRAE 90.1 Section 6.7.2.3- “ System Balancing”

1.5 INFORMATION SUBMITTALS

A. Qualification Data: Within 15 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 15 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. Certified TAB reports.

E. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.6 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by TABB, AABC or NEBB

1. TAB Field Supervisor: Employee of the TAB contractor and certified by TABB, AABC or NEBB.
2. TAB Technician: Employee of the TAB contractor and who is certified by TABB, AABC or NEBB as a TAB technician.

B. TAB Conference: Meet with Commissioning Authority on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide seven days' advance notice of scheduled meeting time and location.

1. Agenda Items:

a. The Contract Documents examination report.
b. The TAB plan.
c. Coordination and cooperation of trades and subcontractors.
d. Coordination of documentation and communication flow.

C. Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard TAB contractor's forms approved by Commissioning Authority.

E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

G. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.7 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.8 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers and other mechanics to operate HVAC systems and equipment to support and assist testing, adjusting and balancing activities.

B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

C. A factory-authorized service representative and the Mechanical Contractor shall be present when balancing and testing major equipment.

D. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine the Contract Documents to become familiar with Project staging plan and to become familiar with the TAB requirements at the end of each construction stage.

C. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

D. Examine the approved submittals for HVAC systems and equipment.

E. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 TESTING, ADJUSTING AND BALANCING

A. At the completion of the project:
1. Perform TAB for the whole system.
2. Generate complete final report.

3.3 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

    a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
    b. Duct systems are complete with terminals installed.
    c. Volume, smoke, and fire dampers are open and functional.
    d. Clean filters are installed.
    e. Fans are operating, free of vibration, and rotating in correct direction.
    f. Variable-frequency controllers' startup is complete and safeties are verified.
    g. Automatic temperature-control systems are operational.
    h. Ceilings are installed.
    i. Windows and doors are installed.
    j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:

    a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
    b. Piping is complete with terminals installed.
    c. Water treatment is complete.
    d. Systems are flushed, filled, and air purged.
    e. Strainers are pulled and cleaned.
    f. Control valves are functioning per the sequence of operation.
    g. Shutoff and balance valves have been verified to be 100 percent open.
    h. Pumps are started and proper rotation is verified.
    i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
    j. Variable-frequency controllers' startup is complete and safeties are verified.
    k. Suitable access to balancing devices and equipment is provided.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

1. Comply with requirements in ASHRAE 62.1-2004, Section 7.2.2, "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Division 23 Section "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section "HVAC Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable –air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Division 23 Section "Metal Ducts."

3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:

    a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
    b. Measure static pressure directly at the fan outlet or through the flexible connection.
    c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.

d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
6. Obtain approval from Commissioning Authority for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 23 Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.7 DUCT LEAKAGE TESTS

A. Witness the duct pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified tolerances.

C. Report deficiencies observed.

3.8 CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify temperature control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.9 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Air handling unit and all other fans: minus 0 percent to plus 10 percent.
2. Minimum Outside air: 0 percent to plus 10 percent.
3. Individual room air outlets and inlets: minus 5 percent to plus 10 percent.

3.10 PROGRESS REPORTING

A. Initial Construction-Stage Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.11 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.

2. Include a list of instruments used for procedures, along with proof of calibration.

B. Final Report Contents: In addition to certified field-report data, include the following:
1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB contractor.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Duct, outlet, and inlet sizes.
3. Balancing stations.
4. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches (mm), and bore.
i. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches (mm), and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).

3. Test Data (Indicated and Actual Values):

a. Total air flow rate in cfm (L/s).
b. Total system static pressure in inches wg (Pa).
c. Fan rpm.
d. Discharge static pressure in inches wg (Pa).
e. Filter static-pressure differential in inches wg (Pa).
f. Preheat-coil static-pressure differential in inches wg (Pa).
g. Cooling-coil static-pressure differential in inches wg (Pa).
h. Heating-coil static-pressure differential in inches wg (Pa).
i. Outdoor airflow in cfm (L/s).
j. Return airflow in cfm (L/s).
k. Outdoor-air damper position.
l. Return-air damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch (mm) o.c.
f. Make and model number.
g. Face area in sq. ft. (sq. m).
h. Tube size in NPS (DN).
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Air flow rate in cfm (L/s).
b. Average face velocity in fpm (m/s).
c. Air pressure drop in inches wg (Pa).
d. Outdoor-air, wet- and dry-bulb temperatures in deg F (deg C).
e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
h. Refrigerant expansion valve and refrigerant types.
i. Refrigerant suction pressure in psig (kPa).
j. Refrigerant suction temperature in deg F (deg C).

G. Gas Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btu/h (kW).
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and rpm.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches (mm), and bore.
n. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).

2. Test Data (Indicated and Actual Values):

a. Total air flow rate in cfm (L/s).
b. Entering-air temperature in deg F (deg C).
c. Leaving-air temperature in deg F (deg C).
d. Air temperature differential in deg F (deg C).
e. Entering-air static pressure in inches wg (Pa).
f. Leaving-air static pressure in inches wg (Pa).
g. Air static-pressure differential in inches wg (Pa).
h. Low-fire fuel input in Btu/h (kW).
i. High-fire fuel input in Btu/h (kW).
j. Manifold pressure in psig (kPa).
k. High-temperature-limit setting in deg F (deg C).
l. Operating set point in Btu/h (kW).
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h (kW).

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.
b. Location.

c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches (mm), and bore.
h. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches (mm), and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm (L/s).
b. Total system static pressure in inches wg (Pa).
c. Fan rpm.
d. Discharge static pressure in inches wg (Pa).
e. Suction static pressure in inches wg (Pa).

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F (deg C).
d. Duct static pressure in inches wg (Pa).
e. Duct size in inches (mm).
f. Duct area in sq. ft. (sq. m).
g. Indicated air flow rate in cfm (L/s).
h. Indicated velocity in fpm (m/s).
i. Actual air flow rate in cfm (L/s).
j. Actual average velocity in fpm (m/s).
k. Barometric pressure in psig (Pa).

J. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.

h. Size.
i. Effective area in sq. ft. (sq. m).

2. Test Data (Indicated and Actual Values):

a. Air flow rate in cfm (L/s).
b. Air velocity in fpm (m/s).
c. Preliminary air flow rate as needed in cfm (L/s).
d. Preliminary velocity as needed in fpm (m/s).
e. Final air flow rate in cfm (L/s).
f. Final velocity in fpm (m/s).
g. Space temperature in deg F (deg C).

K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Air flow rate in cfm (L/s).
b. Entering-water temperature in deg F (deg C).
c. Leaving-water temperature in deg F (deg C).
d. Water pressure drop in feet of head or psig (kPa).
e. Entering-air temperature in deg F (deg C).
f. Leaving-air temperature in deg F (deg C).

L. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model number and serial number.
f. Water flow rate in gpm (L/s).
g. Water pressure differential in feet of head or psig (kPa).
h. Required net positive suction head in feet of head or psig (kPa).
i. Pump rpm.
j. Impeller diameter in inches (mm).
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig (kPa).
b. Pump shutoff pressure in feet of head or psig (kPa).
c. Actual impeller size in inches (mm).
d. Full-open flow rate in gpm (L/s).
e. Full-open pressure in feet of head or psig (kPa).
f. Final discharge pressure in feet of head or psig (kPa).
g. Final suction pressure in feet of head or psig (kPa).
h. Final total pressure in feet of head or psig (kPa).
i. Final water flow rate in gpm (L/s).
j. Voltage at each connection.
k. Amperage for each phase.

M. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.12 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
2. Check the following for each system:

a. Measure airflow of at least 10 percent of air outlets.
b. Measure water flow of at least 5 percent of terminals.
c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
d. Verify that balancing devices are marked with final balance position.
e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:

1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Commissioning Authority.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Commissioning Authority.
3. Commissioning Authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

3.13 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

3.21 FOLLOW-UP SERVICES

A. Allow for three (3) scheduled visits during the six month period following substantial completion to adjust system parameters based on Owner's observations.

END OF SECTION 230593

SECTION 230713 - DUCT INSULATION

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 insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

B. Related Sections:
1. Section 230719 "HVAC Piping Insulation."
2. Section 233113 "Metal Ducts" for duct liners.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

C. HVAC Ducts Requiring Fire-Rated Enclosures: Submit products for fire-rated enclosures for HVAC ductwork, including manufacturer's UL Listings and acceptance by local authority or code having jurisdiction.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless-steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless-steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

    a. CertainTeed Corp.; **SoftTouch Duct Wrap**
    b. Johns Manville; **Microlite**
    c. Knauf Insulation; **Friendly Feel Duct Wrap**
    d. Manson Insulation Inc.; **Alley Wrap**
    e. Owens Corning; **SOFTR All-Service Duct Wrap**

G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

    a. CertainTeed Corp.; **Commercial Board**
    b. Fibrex Insulations Inc.; **FBX**
    c. Johns Manville; **800 Series Spin-Glas**
    d. Knauf Insulation; **Insulation Board**
    e. Manson Insulation Inc.; **AK Board**
    f. Owens Corning; **Fiberglas 700 Series**

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **CP-127**
    b. Eagle Bridges - Marathon Industries; **225**
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **85-60/85-70**
    d. Mon-Eco Industries, Inc.; **22-25**

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **CP-82**
    b. Eagle Bridges - Marathon Industries; **225**
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **85-50**
    d. Mon-Eco Industries, Inc.; **22-25**

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. PVC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **CP-82**
b. Eagle Bridges - Marathon Industries; **225**
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **85-50**
d. Mon-Eco Industries, Inc.; **22-25**

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **30-80/30-90**
b. Vimasco Corporation; **749**

2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: ASTM D 1644, fifty-eight percent (58%) by volume and seventy percent (70%) by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **Encacel**
b. Eagle Bridges - Marathon Industries; **570**
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **60-95/60-96**

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
4. Solids Content: ASTM D 1644, thirty-three percent (33%) by volume and forty-six percent (46%) by weight.
5. Color: White.

2.4 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **CP-50 AHV2**
b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **30-36**
c. Vimasco Corporation; **713** and **714**

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
4. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
5. Color: White.

2.5 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **CP-76**
b. Eagle Bridges - Marathon Industries; **405**
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **95-44**
d. Mon-Eco Industries, Inc.; **44-05**

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide the following:

a. Childers Brand; H. B. Fuller Construction Products; **CP-76**

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.6 FIEFLD APPLIED FABRIC REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering ducts.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B.
b. Fuller Company; **Chil-Glas No. 5**

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for ducts.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B.
b. Fuller Company; **Mast-A-Fab**
c. Vimasco Corporation; **Elastafab 894**

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with Kraft-paper backing; complying with ASTM C1136, Type II.
2. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. Metal Jacket:

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **Metal Jacketing Systems**
b. ITW Insulation Systems; **Aluminum and Stainless-Steel Jacketing**
c. RPR Products, Inc.; **Insul-Mate**

2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. Sheet and roll stock ready for shop or field sizing.
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and Kraft paper.
d. Moisture Barrier for Outdoor Applications: 2.5-mil-thick polysurlyn.

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240.

a. Sheet and roll stock ready for shop or field sizing, or factory cut and rolled to size.
b. Material, finish, and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 1-mil thick, heat-bonded polyethylene and Kraft paper.
d. Moisture Barrier for Outdoor Applications: 2.5-mil thick polysurlyn.

D. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with white aluminum-foil facing.

1. Products: Subject to compliance with requirements, provide the following:

a. Polyguard Products, Inc.; **Alumaguard 60**

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. ABI, Ideal Tape Division; **428 AWF ASJ**
b. Avery Dennison Corporation, Specialty Tapes Division; **Fasson 0836**
c. Compac Corporation; **104** and **105**
d. Venture Tape; **1540 CW Plus**, **1542 CW Plus**, and **1542 CW Plus/SQ**

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: Two percent (2%).
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. ABI, Ideal Tape Division; **491 AWF FSK**
b. Avery Dennison Corporation, Specialty Tapes Division; **Fasson 0827**
c. Compac Corporation; **110** and **111**
d. Venture Tape; **1525 CW NT**, **1528 CW**, and **1528 CW/SQ**

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: Two percent (2%).
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. ABI, Ideal Tape Division; **491 AWF FSK**
b. Avery Dennison Corporation, Specialty Tapes Division; **Fasson 0827**
c. Compac Corporation; **110** and **111**
d. Venture Tape; **1525 CW NT**, **1528 CW**, and **1528 CW/SQ**

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: Five hundred percent (500%).
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. ABI, Ideal Tape Division; **488 AWF**
b. Avery Dennison Corporation, Specialty Tapes Division; **Fasson 0800**
c. Compac Corporation; **120**
d. Venture Tape; **3520 CW**

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: Five percent (5%).
6. Tensile Strength: 34 lbf/inch in width.

2.10 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. ITW Insulation Systems; **Gerrard Strapping and Seals**
b. RPR Products, Inc.; **Insul-Mate Strapping, Seals, and Springs**

2. Stainless-Steel: ASTM A 167 or ASTM A 240, Type 304; 0.015-inch-thick, ¾-inch-wide with wing seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-or 0.135-inch-diameter shank, length to suit depth of insulation indicated.

a. Products: Subject to compliance with requirements, provide one (1) of the following:

1) AGM Industries, Inc.; **CWP-1**
2) GEMCO; **CD**
3) Midwest Fasteners, Inc.; **CD**

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch-diameter shank, length to suit depth of insulation indicated with integral 1½-inch galvanized carbon-steel washer.

    a. Products: Subject to compliance with requirements, provide one (1) of the following:

        1) AGM Industries, Inc.; **CHP-1**
        2) GEMCO; **Cupped Head Weld Pin**
        3) Midwest Fasteners, Inc.; **Cupped Head**
        4) Nelson Stud Welding; **CHP**

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

    a. Products: Subject to compliance with requirements, provide one (1) of the following:

        1) AGM Industries, Inc.; **CHP-1**
        2) GEMCO; **Cupped Head Weld Pin**
        3) Midwest Fasteners, Inc.; **Cupped Head**

    b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030-inch-thick by 2 inches square.
    c. Spindle: Copper- or zinc-coated, low-carbon steel, aluminum, stainless-steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
    d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1½ inches in diameter.

    a. Products: Subject to compliance with requirements, provide one (1) of the following:

        1) AGM Industries, Inc.; **RC-150**
        2) GEMCO; **R-150**
        3) Midwest Fasteners, Inc.; **WA-150**
        4) Nelson Stud Welding; **Speed Clips**

    b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

C. Staples: Outward-clinching insulation staples, nominal ¾-inch-wide, stainless-steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel.

1. Manufacturers: Subject to compliance with requirements available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. C & F Wire

2.11 CORNER ANGLES

A. Aluminum Corner Angles: 0.040-inch-thick, minimum 1-by-1-inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

B. Stainless-Steel Corner Angles: 0.024-inch-thick, minimum 1-by-1-inch, stainless-steel according to ASTM A 167 or ASTM A 240, Type 304.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces, free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1½ inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than seventy-five percent (75%) of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Section 078413 "Penetration Firestopping."

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for one hundred percent (100%) coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Impale insulation over pins and attach speed washers.
    f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one (1) edge and one (1) end of insulation segment. Secure laps to adjacent insulation section with ½-inch outward-clinching staples, 1-inch

o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two (2) times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for one hundred percent (100%) coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
d. Do not overcompress insulation during installation.
e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one (1) edge and one (1) end of insulation segment. Secure laps to adjacent insulation section with ½-inch outward-clinching staples, 1-inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface.

Cover insulation face and surface to be insulated a width equal to two (2) times the insulation thickness, but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.6 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below.

1. Flat Acrylic Finish: Two (2) finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Color: Final color as selected by Architect and Owner from manufacturer’s entire range. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless-steel jackets.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location for each duct system defined in the "Duct Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.8 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

B. Items Not Insulated:
1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1. Refer to Section 233113 “Metal Ducts” for duct liner requirements.
2. Factory-insulated flexible ducts.

3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Vibration-control devices.
6. Factory-insulated access panels and doors.

3.9 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, round and flat-oval, supply-air duct insulation shall be**:**

1. Mineral-Fiber Blanket: Minimum installed R Value of 6 and 0.75-lb/cu. ft. nominal density.

B. Concealed, round and flat-oval, return-air duct insulation shall be:

1. Mineral-Fiber Blanket: Minimum installed R Value of 6 and 0.75-lb/cu. ft. nominal density.

C. Concealed, round and flat-oval, outdoor-air duct insulation shall be:

1. Mineral-Fiber Blanket: Minimum installed R Value of 6 and 0.75-lb/cu. ft. nominal density.

D. Concealed, round and flat-oval, exhaust-air duct insulation shall be:

1. Mineral-Fiber Blanket: Minimum installed R Value of 6 and 0.75-lb/cu. ft. nominal density.

E. Concealed, rectangular, supply-air duct insulation shall be:

1. Mineral-Fiber Blanket: Minimum installed R Value of 6 and 0.75-lb/cu. ft. nominal density.

F. Concealed, rectangular, return-air duct insulation shall be:

1. Mineral-Fiber Blanket: Minimum installed R Value of 6 and 0.75-lb/cu. ft. nominal density.

G. Concealed, rectangular, outdoor-air duct insulation shall be:

1. Mineral-Fiber Blanket: Minimum installed R Value of 6 and 0.75-lb/cu. ft. nominal density.

H. Concealed, rectangular, exhaust-air and outside air duct insulation between isolation damper and penetration of building exterior shall be the following:

1. Mineral-Fiber Blanket: Minimum installed R Value of 12 and 0.75-lb/cu. ft. nominal density.

I. Concealed, supply-air plenum insulation shall be:

1. Mineral-Fiber Blanket: Minimum installed R Value of 6 and 0.75-lb/cu. ft. nominal density.

J. Concealed, return-air plenum insulation shall be:

1. Mineral-Fiber Blanket: Minimum installed R Value of 6 and 0.75-lb/cu. ft. nominal density.

K. Concealed, outdoor-air plenum insulation shall be:

1. Mineral-Fiber Blanket: Minimum installed R Value of 6 and 0.75-lb/cu. ft. nominal density.

L. Concealed, exhaust-air plenum insulation shall be:

1. Mineral-Fiber Blanket: Minimum installed R Value of 6 and 0.75-lb/cu. ft. nominal density.

M. Exposed, supply-air plenum insulation shall be:

1. Mineral-Fiber Board: Minimum installed R Value of 6 and 1.5-lb/cu. ft. nominal density.

N. Exposed, return-air plenum insulation shall be:

1. Mineral-Fiber Board: Minimum installed R Value of 6 and 1.5-lb/cu. ft. nominal density.

O. Exposed, outdoor-air plenum insulation shall be:

1. Mineral-Fiber Board: Minimum installed R Value of 6 and 1.5-lb/cu. ft. nominal density.

P. Exposed, exhaust-air plenum insulation shall be:

1. Mineral-Fiber Board: Minimum installed R Value of 5 and 1.5-lb/cu. ft. nominal density.

Q. Concealed and Exposed, supply, return, exhaust and outdoor-air ductwork and plenum located outside the building envelop insulation shall be:

1. Mineral-Fiber Board: Minimum installed R Value of 12 and 3-lb/cu. ft. nominal density.

3.10 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one (1) material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums, Concealed:

1. None.

D. Ducts and Plenums, Exposed:

1. Painted Aluminum, Smooth: 0.016-inch-thick.

END OF SECTION 230713

SECTION 230719 - HVAC PIPING INSULATION

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 insulation for the following HVAC piping systems:
   1. Refrigerant liquid, suction, hot-gas, discharge, and heat recovery piping.
   2. Condensate drain piping.

B. Related Sections:

   1. Section 230713 "Duct Insulation" for duct insulation.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail attachment and covering of heat tracing inside insulation.
   3. Detail insulation application at pipe expansion joints for each type of insulation.
   4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
   5. Detail removable insulation at piping specialties.
   6. Detail application of field-applied jackets.
   7. Detail application at linkages of control devices.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come into contact with stainless-steel shall have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C 871.

D. Insulation materials for use on austenitic stainless-steel shall be qualified as acceptable in accordance with ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534/C534M, Type I for tubular materials.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Aeroflex USA, Inc.; **Aerocel**
b. Armacell LLC; **AP Armaflex**
c. K-Flex USA; **Insul-Lock**, **Insul-Tube**, and **K-FLEX LS**

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Aeroflex USA, Inc.; **Aeroseal**
b. Armacell LLC; **Armaflex 520 Adhesive**
c. K-Flex USA; **R-373 Contact Adhesive**

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Adhesive and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **CP-82**
b. Eagle Bridges - Marathon Industries; **225**
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **85-50**
d. Mon-Eco Industries, Inc.; **22-25**

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Childers Brand; H. B. Fuller Construction Products; **Encacel**
b. Eagle Bridges - Marathon Industries
c. Foster Brand; H. B. Fuller Construction Products; **60-95/60-96**

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Solids Content: ASTM D 1644, thirty-three percent (33%) by volume and forty-six percent (46%) by weight.
5. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **CP-10**
    b. Eagle Bridges - Marathon Industries; **550**
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **46-50**
    d. Mon-Eco Industries, Inc.; **55-50**
    e. Vimasco Corporation; **WC-1/WC-5**

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: Sixty percent (60%) by volume and sixty-six percent (66%) by weight.
5. Color: White.

2.4 LAGGING ADHESIVES

A. Adhesives shall comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, provide one of the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **CP-50 AHV2**
    b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **30-36**
    c. Vimasco Corporation; **713** and **714**

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
4. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
5. Color: White.

2.5 SEALANTS

A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:
1. Permanently flexible, elastomeric sealant.
2. Service Temperature Range: Minus 100 to plus 300 deg F.
3. Color: White or gray.
4. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.6 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 1136, Type I, unless otherwise indicated.

B. Metal Jacket:

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; **Metal Jacketing Systems**
b. ITW Insulation Systems; **Aluminum and Stainless-Steel Jacketing**
c. RPR Products, Inc.; **Insul-Mate**

2. Stainless-Steel Jacket: ASTM A 240.

a. Factory cut and rolled to size.
b. Material, finish, and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and Kraft paper.
d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and Kraft paper, or 2.5-mil- thick polysurlyn.
e. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.7 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. ABI, Ideal Tape Division; **428 AWF ASJ**
b. Avery Dennison Corporation, Specialty Tapes Division; **Fasson 0836**
c. Compac Corporation; **104** and **105**
d. Venture Tape; **1540 CW Plus**, **1542 CW Plus**, and **1542 CW Plus/SQ**

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: Two percent (2%).
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. ABI, Ideal Tape Division; **491 AWF FSK**
b. Avery Dennison Corporation, Specialty Tapes Division; **Fasson 0827**
c. Compac Corporation; **110** and **111**
d. Venture Tape; **1525 CW NT**, **1528 CW**, and **1528 CW/SQ**

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: Two percent (2%).
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Compac Corporation; **130**
b. Venture Tape; **1506 CW NS**

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: Five hundred percent (500%).
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. ABI, Ideal Tape Division; **488 AWF**
b. Avery Dennison Corporation, Specialty Tapes Division; **Fasson 0800**
c. Compac Corporation; **120**
d. Venture Tape; **3520 CW**

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: Five percent (5%).
6. Tensile Strength: 34 lbf/inch in width.

2.8 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. ITW Insulation Systems; **Gerrard Strapping and Seals**
b. RPR Products, Inc.; **Insul-Mate Strapping, Seals, and Springs**

2. Stainless-Steel: ASTM A 167 or ASTM A 240, Type 304, ½-inch-wide with wing seal.

B. Staples: Outward-clinching insulation staples, nominal ¾-inch-wide, stainless-steel or Monel.

C. Wire: 0.062-inch soft-annealed, stainless-steel.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. C & F Wire

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless-Steel: Coat 300 series stainless-steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature of between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1½ inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 2 inches o.c.

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than twenty-five percent (25%) of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.

3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as that of adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as that used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than two (2) times the thickness of pipe insulation, or one (1) pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than two (2) times the thickness of pipe insulation, or one (1) pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers, so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges, mechanical couplings, and unions using a section of oversized preformed pipe insulation to fit. Overlap adjoining pipe insulation by not less than two (2) times the thickness of pipe insulation, or one (1) pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as that of adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least two (2) times the insulation thickness over adjacent pipe

insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two (2) halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two (2) coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as that of pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as that of pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.

3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1-inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as that of straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as that of straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.8 FIELD-APPLIED JACKET INSTALLATION

A. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.9 FINISHES

A. Pipe insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below.

1. Flat Acrylic Finish: Two (2) finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two (2) coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect and Owner from manufacturer's entire range. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three (3) locations of straight pipe, three (3) locations of threaded fittings, three (3) locations of welded fittings, two (2) locations of threaded strainers, two (2) locations of welded strainers, three (3) locations of threaded valves, and three (3) locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.11 PIPING INSULATION SCHEDULE, GENERAL

A. Insulation conductivity and thickness per pipe size shall comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Underground piping.
2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.12 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation shall be one (1) of the following:

a. Mineral-Fiber, Preformed Pipe Insulation, Type I, 1-inch-thick.
b. Flexible Elastomeric: 1-inch-thick.

B. Refrigerant Liquid, Suction and Hot-Gas Piping:

1. NPS 1 1/2 and Smaller: Insulation shall be one (1) of the following:
a. Flexible Elastomeric: 1-inch-thick.

C. Refrigerant Liquid, Suction and Hot-Gas Flexible Tubing:

1. All Sizes: Insulation shall be the following:

a. Flexible Elastomeric: 1-inch-thick.

3.13 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Refrigerant Liquid, Suction and Hot-Gas Piping:

1. All Sizes: Insulation shall be:

a. Flexible Elastomeric, 2 inches thick.

B. Refrigerant Liquid, Suction and Hot-Gas Tubing:

1. All Sizes: Insulation shall be:
a. Flexible Elastomeric, 2 inches thick.

3.14 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one (1) material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.

D. Piping, Exposed:

1. PVC: 20 mils thick.

3.15 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Piping, Exposed:

1. Stainless-Steel, Type 304 or 316, Smooth 2B Finish with Z-Shaped Locking Seam: 0.020-inch-thick.

END OF SECTION 230719

SECTION 230923 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this section shall be bound by the Related Documents identified in Division 01 Section Summary.

1.2 SECTION INCLUDES

A. A fully integrated Tridium Niagara 4 Honeywell WEBs HVAC Instrumentation and Control Building System, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as herein specified.

B. A complete fully integrated HVAC Instrumentation and Control Building System incorporating Direct Digital Control, Electric & Electronic Control, and Building System Control Interfaces; including devices, controllers, cabling, installation, and implementation of the sequences of operation listed herein as required for a complete operable and maintainable system.

C. All power and control wiring to all control system equipment including, but not limited to, control panels, motorized dampers and valve actuators, control transformers, air terminal unit actuators, time clocks, relays, transformers, PE switches, remote switches, and all other control devices. Coordinate requirements with Division 26.

D. All control wiring to terminal strips, field wiring from terminal strips to field mounted devices, wiring to the “auto” side of hand-off-auto switches on units being controlled by the controls contractor, wiring of all electro-mechanical devices required to be located on or in temperature control panels.

E. Interlock wiring from a fire alarm system interface device and/or duct smoke detector relay contact to unit control circuit for system shutdown, including all necessary relays and devices rated for voltages and amperages involved. Coordinate with Division 28 Section “Fire Alarm”.

F. Provide programmable controllers and interconnecting wiring for cabinet unit heaters, unit heaters, ceiling radiant panels, finned tube radiation, ductless split system and similar terminal units. These units shall be furnished configured to accept control inputs from an external building automation system controller as specified in Section 23 09 00. Factory mounted safeties and other controls shall not interfere with this controller.

G. Products Furnished But Not Installed Under This Section

1. Sensors and Transmitters:
   a. Refrigerant pressure and temperature sensor wells and sockets
   b. Differential pressure wells and switches
2. Decentralized HVAC Equipment
   a. 1. Terminal unit controls

H. Products Installed But Not Furnished Under This Section

1. Section 28 - Fire Detection and Alarm:
2. Smoke Detectors

I. Products Not Furnished or Installed but integrated with the Work of this Section

1. General:
   a. Coordination Meeting: The Installer furnishing the DDC network shall meet with the Installer(s) furnishing each of the following products to coordinate details of the interface between these products and the DDC network. The Owner or his designated representative shall be present at this meeting. Each Installer shall provide the Owner and all other Installers with details of the proposed interface including PICS for BACnet equipment, hardware and software identifiers for the interface points, network identifiers, wiring requirements, communication speeds, and required network accessories. The purpose of this meeting shall be to insure there are no unresolved issues regarding the integration of these products into the DDC network. Submittals for these products shall not be approved prior to the completion of this meeting.
2. Section 23 72 20 – Energy Recovery Ventilators
   a. The Energy Recovery Ventilator shall be furnished with integral control with BacNet Interface for integration into the Direct Digital Control System described in this section.
3. Communications with Third Party Equipment:
   a. Any additional integral control systems included with the products integrated with the work of this section shall be furnished with a BACnet interface for integration into the Direct Digital Control System described in this section.

J. Programming and complete graphical interface for ease of user interaction with all the School HVAC systems. The graphics shall provide an easy to understand schematic diagram or flow diagram for each type of equipment with all the points and alarm conditions shown on the diagram.

K. Creation of the building floor plan graphics indicating space temperatures, alarms and associated equipment.

1.3 RELATED SECTIONS

A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.

B. The following sections constitute related work:

1. Section 01 60 00 " Product Requirements"
2. Section 23 00 00 "Basic Mechanical Requirements"
3. Section 23 09 93 "Sequence of Operations For HVAC Controls"
4. Section 23 34 23 " HVAC Power Ventilators"
5. Section 23 62 00 " Packaged Roof top Air Conditioning Units"
6. Section 23 74 24 " Packaged Makeup Air Unit"

7. Section 23 74 33 “Dedicated Outdoor Air Units”
8. Section 23 81 29 “Variable Refrigerant Flow HVAC Systems”
9. Section 23 81 26 “Split System Air Conditioning Units”
10. Section 23 82 13 “Radiant Heating Hydronic Panels”
11. Section 23 82 33 “ Convectors”
12. Section 23 82 36 “ Finned Tube Radiation Heaters”
13. Section 23 82 39.13 “ Cabinet Unit Heaters”
14. Section 23 82 39.16 “ Propeller Unit Heaters
15. Section 238413.29 “Electrode Steam Humidifier”
16. Communications Cabling:
    a. Section 260523 "Control-Voltage Electrical Power Cables" for balanced twisted pair communications cable.
    b. Section 271513 "Communications Copper Horizontal Cabling" for balanced twisted pair communications cable.
    c. Section 271523 "Communications Optical Fiber Horizontal Cabling" for optical fiber communications cable.

17. Raceways:
    a. Section 260533 "Raceways and Boxes for Electrical Systems" for raceways for low-voltage control cable.
    b. Section 270528 "Pathways for Communications Systems" for raceways for balanced twisted pair cabling and optical fiber cable.

1.4 SYSTEM DESCRIPTION

A. General: The Tridium Niagara 4 Honeywell WEBs control system shall consist of a high-speed, peer-to-peer network of DDC controllers, a control system server, and a web-based operator interface.

B. The Building Management System (BMS) shall comprise of a network of interoperable, stand-alone digital controllers, a network area controller, graphics and programming and other control devices for a complete system as specified herein.

C. The installed system shall provide secure password access to all features, functions and data contained in the overall BMS.

A. All field controllers shall be fully programmable.

B. The System Integrator shall provide as part of the submittals a copy of the Niagara Compatibility Statement (NiCS) verifying that all aspect of the Niagara Framework as provided maintain an Open System Design. The System as provided shall confirm with the following NiCS

Property	Value
STATION COMPATIBILITY IN	All
STATION COMPATIBILITY OUT	All
TOOL COMPATIBILITY IN	All
TOOL COMPATIBILITY OUT	All

C. Provide remote access via WEB/Mobile Brower and mobile applications for unlimited users without requiring proprietary software fees, seat licensing or restricted/annual licensing.

D. All building automation controllers and peripherals are required to be readily available from multiple local sources for direct purchase. Single source availability of said devices is not acceptable.

E. The BAS system must be programmed utilizing a non-proprietary software tool such as Niagara Workbench. Additional software for configuration is not permitted. Proprietary software configuration tools are not acceptable. Copy of Niagara Workbench to be provided to owner after project completion.

F. Owner to receive administration rights to all features, functionality and configuration of the building automation system

G. Software Tools - All software tools needed for full functional use, including programming of BCs and DDC, network management and expansion, and graphical user interface development, of the BAS described within these specifications, shall be provided to the owner or his designated agent. Any licensing required by the manufacturer now and into the future, including changes to the licensee of the software tools and the addition of hardware corresponding to the licenses, to allow for a complete and operational system for both normal day to day operation and servicing shall be provided. Any such changes to the designated license holders shall be made by the manufacturer upon written request by the owner or his agent. Any cost associated with the license changes shall be identified within the BAS submittals.

H. Programming Tools - Provide freely available Niagara 4 Wizards to facilitate the programming and configuration of all of the DDC devices that are provided for the HVAC and lighting control. Wizards shall be provided free of charge and be compatible with the current published versions of the network management tool that is provided as part of this project. The wizard software shall be available for public access from the manufacturer's web site. These wizard programming tools shall be compatible with at least 3 other brands of the Niagara Framework network management tools. The SI shall demonstrate as part of their prequalification as to how they intend to comply with these requirements.

I. Software License Agreement - The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights as it relates to disclosure of trade secrets contained within said software. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). In addition, the Owner shall receive ownership of all job specific configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code, databases and documentation for all configuration and programming that is generated for a given project and/or configured for use with the BC, BAS Server(s), and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required IDs and passwords for access to any component or software program shall be provided to the owner.

1.2 Quality Assurance

A. General - The HVAC Control System shall be furnished, engineered, and installed by a licensed Controls Contractor or System Integrator (SI) for a minimum of 10 years. All work provided under this section shall be provided by direct employees of the SI or under the direct supervision of the SI personnel.

B. System Integrator Qualifications

1. The SI must be regularly engaged in the service and installation of Honeywell WEBs BACnet, and Niagara 4 based systems as specified herein, The SI shall have a minimum of 10 years' experience in the sales, installation, engineering, programming servicing and commissioning of the Niagara4 platform and the field controllers as proposed
2. The system integrator must be an authorized factory direct representative in good standing of the manufacturer of the proposed hardware and software components.

Provide a letter dated within the last 6 months, from the manufacture certifying that the System Integrator is an authorized factory direct representative.

3. The SI shall have an office within 50 miles of the Building site that is staffed with a minimum of fifteen (12) certified technicians who have successfully completed the factory authorized training of the proposed manufactures hardware and software components and have successfully completed a Niagara 4 certification course. supplying complete maintenance. SI must provide proof of required training. The SI capabilities shall include engineering and design of control systems, programming, electrical installation of control systems, troubling shooting and service. **SI shall be staffed to provide support services on a 24 hour, 7-day-a-week basis**.
4. The SI shall submit a list of no less than three (3) similar projects, which have similar Building Automation Systems as specified herein installed by the SI. These projects must be on-line and functional such that the Owner's/User's representative can observe the system in full operation.

C. Hardware and Software Component Manufacturer Qualifications

1. The manufacturer of the hardware and software components must be primarily engaged in the manufacture of both LonWorks and BACnet based systems as specified herein, and must have been so for a minimum of five (5) years. The manufacturer shall demonstrate that they are the manufacturer of all DDC devices and Niagara 4 products provided.
2. The manufacturer of the hardware and software components as well as its subsidiaries must be a member in good standing of the BACnet International, and the BACnet Manufacturers Association.
3. The manufacturer of the hardware and software components shall have a technical support group accessible via a toll free number that is staffed with qualified personnel, capable of providing instruction and technical support service for networked control systems.

1.5 SYSTEM PERFORMANCE

A. Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).

1. Graphic Display.A graphic with 20 dynamic points shall display with current data within 10 sec.
2. Graphic Refresh.A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.
3. Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.
4. Object Command. Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.
5. Alarm Response Time. An object that goes into alarm shall be annunciated at the workstation within 45 sec.
6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.

7. Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.
8. Multiple Alarm Annunciation. Each workstation on the network shall receive alarms within 5 sec of other workstations.
9. Reporting Accuracy. System shall report values with minimum end-to-end accuracy listed in Table 1.
10. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.

Table-1
Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.5ºC (±1ºF)
Ducted Air	±0.5ºC (±1ºF)
Outside Air	±1.0ºC (±2ºF)
Dew Point	±1.5ºC (±3ºF)
Water Temperature	±0.5ºC (±1ºF)
Delta-T	±0.15º (±0.25ºF)
Relative Humidity	±5% RH
Water Flow	±2% of full scale
Airflow (terminal)	±10% of full scale (see Note 1)
Airflow (measuring stations)	±5% of full scale
Airflow (pressurized spaces)	±3% of full scale
Air Pressure (ducts)	±25 Pa (±0.1 in. w.g.)
Air Pressure (space)	±3 Pa (±0.01 in. w.g.)
Water Pressure	±2% of full scale (see Note 2)
Electrical	±1% of reading (see Note 3)
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO2)	±50 ppm

Note 1: Accuracy applies to 10%–100% of scale
Note 2: For both absolute and differential pressure
Note 3: Not including utility-supplied meters

Table 2
Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±50 Pa (±0.2 in. w.g.) ±3 Pa (±0.01 in. w.g.)	0–1.5 kPa (0–6 in. w.g.) -25 to 25 Pa (-0.1 to 0.1 in. w.g.)
Airflow	±10% of full scale	
Space Temperature	±1.0ºC (±2.0ºF)	
Duct Temperature	±1.5ºC (±3ºF)	
Humidity	±5% RH	
Fluid Pressure	±10 kPa (±1.5 psi) ±250 Pa (±1.0 in. w.g.)	MPa (1–150 psi) 0–12.5 kPa (0–50 in. w.g.) differential

1.6 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. BACnet Specific Definitions:

1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network.
2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.

D. Binary: Two-state signal where a high signal level represents ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.

F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

G. COV: Changes of value.

H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated. DDC System Provider shall have having full-time in-house employees for the following:

1. Engineering: Engineering shall be responsible to generate a sequence of operations and control drawings based on the contract documents for the submittal process.
2. Programmer: Programmer shall be responsible to write the code into the controllers as required to execute the sequence of operations.

I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.

J. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

K. HLC: Heavy load conditions.

L. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

M. LAN: Local area network.

N. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

O. Modbus TCP/IP: An open protocol for exchange of process data.

P. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

Q. MTBF: Mean time between failures.

R. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.

S. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

T. Peer to Peer: Networking architecture that treats all network stations as equal partners.

U. POT: Portable operator's terminal.

V. PUE: Performance usage effectiveness.

W. RAM: Random access memory.

X. RF: Radio frequency.

Y. Router: Device connecting two or more networks at network layer.

Z. Server: Computer used to maintain system configuration, historical and programming database.

AA. TCP/IP: Transport control protocol/Internet protocol.

BB. UPS: Uninterruptible power supply.

CC. USB: Universal Serial Bus.

DD. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

EE. VAV: Variable air volume.

FF. WLED: White light emitting diode.

1.7 PREINSTALLATION MEETINGS

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

1.8 ACTION SUBMITTALS

A. Multiple Submissions:

1. If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.
2. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
3. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.

B. Product Data: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
    a. Workstations.
    b. Servers.
    c. Printers.
    d. Gateways.
    e. Routers.
    f. Protocol analyzers.
    g. DDC controllers.
    h. Enclosures.
    i. Electrical power devices.
    j. UPS units.
    k. Accessories.
    l. Instruments.
    m. Control dampers and actuators.
    n. Control valves and actuators.

6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

C. Software Submittal:

1. Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, and DDC controller.
2. Description and technical data of all software provided, and cross-referenced to products in which software will be installed.
3. Operating system software, operator interface and programming software, color graphic software, DDC controller software and maintenance management software, and third-party software.
4. Description of each network communication protocol.

D. Shop Drawings:

1. General Requirements:
   a. Include cover drawing with Project name, location, Owner, Architect, Contractor and issue date with each Shop Drawings submission.
   b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
   c. Prepare Drawings using CAD.
   d. Drawings Size: 11 inches by 17 inches.
   e. Drawings shall be available on CD-ROM.
2. Schematic drawings for each controlled HVAC system indicating the following:
   a. I/O points labeled with point names shown.
   b. A graphic showing location of control I/O in proper relationship to HVAC system.
   c. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
   d. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays, and interface to DDC controllers.
   e. Graphic sequence of operation, showing all inputs and output logical blocks.
3. System Documentation
   a. Include the following in submittal package:
      1) System configuration diagrams in simplified block format.
      2) Riser diagrams showing control network layout, communication protocol, and wire types.
      3) Complete description of control system operation including sequences of operation. Include and reference schematic diagram of all controlled system, including units with manufacturer furnished controls.
      4) All input/output object listings and an alarm point summary listing.
      5) Electrical drawings that show all system internal and external connection points, terminal block layouts, and terminal identification.
      6) Complete bill of materials, valve schedule and damper schedule.
      7) Manufacturer's instructions and drawings for installation, maintenance, and operation of all purchased items.
      8) Overall system operation and maintenance instructions—including preventive maintenance and troubleshooting instructions.
      9) For all system elements—operator’s workstation(s), building controller(s), application controllers, routers, and repeaters—provide BACnet Protocol Implementation Conformance Statements (PICS) as per ANSI/ASHRAE Standard 135-2001.
      10) Provide complete description and documentation of any proprietary (non-BACnet) services and/or objects used in the system.

11) A list of all functions available and a sample of function block programming that shall be part of delivered system.
12) Provide BACNet conformance statement.

b. Include cover drawing with Project name, location, Owner, Architect, Contractor and issue date with each Shop Drawings submission.
c. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
d. Prepare Drawings using CAD.
e. Drawings Size: 11” X 17” (ANSI B).

4. Project Management
   a. The vendor shall provide a detailed project design and installation schedule with time markings and details for hardware items and software development phases. Schedule shall show all the target dates for transmission of project information and documents, and shall indicate timing and dates for system installation, debugging, and commissioning.

1.9 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. Systems Provider Qualification Data:
   a. Resume of project manager assigned to Project.
   b. Resumes of application engineering staff assigned to Project.
   c. Resumes of installation and programming technicians assigned to Project.
   d. Resumes of service technicians assigned to Project.
   e. Brief description of past project including physical address, floor area, number of floors, building system cooling and heating capacity, and building's primary function.
   f. Description of past project DDC system, noting similarities to Project scope and complexity indicated.
   g. Owner contact information for past project including name, phone number, and e-mail address.
   h. Contractor contact information for past project including name, phone number, and e-mail address.
   i. Architect and Engineer contact information for past project including name, phone number, and e-mail address.
2. Manufacturer's qualification data.
3. Testing agency's qualifications data.

B. Product Certificates:

1. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135.

C. Sample Warranty: For manufacturer's warranty.

1.10 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.

b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
c. As-built versions of submittal Product Data.
d. Names, addresses, e-mail addresses, and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
g. Engineering, installation, and maintenance manuals that explain how to:
    1) Design and install new points, panels, and other hardware.
    2) Perform preventive maintenance and calibration.
    3) Debug hardware problems.
    4) Repair or replace hardware.
h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
j. Licenses, guarantees, and warranty documents.
k. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
l. Owner training materials.

1.11 QUALITY ASSURANCE

A. General

1. The Building Automation System (BAS) system shall be designed, installed, commissioned, and serviced by manufacturer authorized and trained personnel. System provider shall have an in-place support facility within 2 hours response time of the site with technical staff, spare parts inventory, and necessary test and diagnostic equipment.
2. Materials and equipment shall be manufacturer's latest standard design that complies with the specification requirements.
3. All BAS peer-to-peer network controllers, central system controllers and local user displays shall be UL Listed under Standard UL 916, category PAZX.
4. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

B. DDC System Manufacturer Qualifications:

1. Nationally recognized manufacturer of DDC systems and products.
2. DDC systems with similar requirements to those indicated for a continuous period of 10 years within time of bid.
3. DDC systems and products that have been successfully tested and in use on at least one hundred past projects.
4. Having complete published catalog literature, installation, operation, and maintenance manuals for all products intended for use.
5. Having full-time in-house employees for the following:

    a. Product research and development.
    b. Product and application engineering.

c. Technical support for DDC system installation training, commissioning, and troubleshooting of installations.
d. Owner operator training.

C. DDC System Provider Qualifications:

1. Authorized representative of, and trained by DDC system manufacturer.
2. DDC system provider shall have in-house employee for engineering staff
3. and programmer.
4. In-place facility located within 50 miles of Project and located within the State of Connecticut
5. The DDC system provider shall be regularly engaged in the design, installation and maintenance of BAS systems and shall have demonstrated technical expertise and experience in the design, installation and maintenance of systems similar in size and complexity to this project. DDC system provider shall provide a list of at least 20 projects, similar in size and scope to this project completed within the past 10 years.
6. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
7. Service and maintenance staff assigned to support Project during warranty period.
8. Product parts inventory to support on-going DDC system operation for a period of not less than 5 years after Substantial Completion.
9. The HVAC Control System shall be furnished, engineered, and installed by a licensed Controls Contractor or System Integrator (SI) for a minimum of 10 years. All work provided under this section shall be provided by direct employees of the SI or under the direct supervision of the SI personnel.
10. System Integrator Qualifications
    4. The SI must be regularly engaged in the service and installation of Honeywell WEBs BACnet, and Niagara 4 based systems as specified herein, The SI shall have a minimum of 10 years' experience in the sales, installation, engineering, programming servicing and commissioning of the Niagara4 platform and the field controllers as proposed
    5. The system integrator must be an authorized factory direct representative in good standing of the manufacturer of the proposed hardware and software components. Provide a letter dated within the last 6 months, from the manufacture certifying that the System Integrator is an authorized factory direct representative.
    6. The SI shall have an office within 50 miles of the Building site that is staffed with a minimum of fifteen (12) certified technicians who have successfully completed the factory authorized training of the proposed manufactures hardware and software components and have successfully completed a Niagara 4 certification course. supplying complete maintenance. SI must provide proof of required training. The SI capabilities shall include engineering and design of control systems, programming, electrical installation of control systems, troubling shooting and service. **SI shall be staffed to provide support services on a 24 hour, 7-day-a-week basis**.
    7. The SI shall submit a list of no less than three (3) similar projects, which have similar Building Automation Systems as specified herein installed by the SI. These projects must be on-line and functional such that the Owner's/User's representative can observe the system in full operation.

1.12 REFERENCE STANDARDS

A. The latest edition of the following standards and codes in effect and amended as of supplier's proposal date, and any applicable subsections thereof, shall govern design and selection of equipment and material supplied:

1. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).

2. ANSI/ASHRAE Standard 135-2008, BACnet.

3. International Building Code (IBC), including local amendments.

4. International Mechanical Code (IMC).

5. UL 916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.

6. National Electrical Code (NEC).

7. UL-864 UUKL listing for Smoke Controls for any equipment used in smoke control sequences.

B. Except as otherwise indicated, the system supplier shall secure and pay for all permits, inspections, and certifications required for his work, and arrange for necessary approvals by the governing authorities.

1.13 WARRANTY

A. Warranty will commence as the construction phases are completed.

B. Warranty period will be twelve(12) months after the equipment /system has been put into permanent operating mode, equipment/system and components have been commissioned by the Commissioning Agent and accepted, and the operating and maintenance manuals have been submitted and approved.

C. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of one year from completion of system acceptance.

D. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours, Monday through Friday and 48 hours on Saturday and Sunday.

E. This warranty shall apply equally to both hardware and software.

F. JACE 8000 and Niagara 4 Supervisor shall be provided with 3 Year SMA (Software Maintenance Agreement)

PART 2 - PRODUCTS

2.1 DDC SYSTEM MANUFACTURERS

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

1. Honeywell WEBs by ESC. Contact Rob Croston 860-471-1941

B. Control systems shall comply with the terms of this specification.

C. The Contractor shall use operator workstation software, controller software, custom application programming language, and controllers from the corresponding manufacturer and product line unless Owner approves use of multiple manufacturers.

D. Other products specified herein (such as sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.

2.2 MATERIALS

A. Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five years after completion of this contract

2.3 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURE

A. The system provided shall incorporate hardware and software resources sufficient to meet the functional requirements of these Specifications. The Facility Local Area Network (FAC LAN) and Device Level Network (DLN) shall be based on industry standard open platforms as specified herein and utilize commonly available operation, management and application software. All software packages and databases shall be licensed to the Owner to allow unrestricted maintenance and operation of the IAS. Contractor shall include all items not specifically itemized in these Specifications that are necessary to implement, maintain, and operate the system in compliance with the functional intent of these Specifications. The lastest version of Niagara 4 shall be utilized.

B. The system architecture shall implement a new building and consists of an Ethernet-based, wide area network (WAN), a single Local Area Network (LAN) that supports NCs, PCUs, ASCs, Operator Workstations (OWS), Smart Devices (SD), and Remote Communication Devices (RCDs) as applicable.

1. Facility Local Area Network (FAC LAN): The FAC LAN shall be an Ethernet-based, 10/100/1000 Ethernet LAN connecting Local NCs, IAS Server and OWSs. The FAC LAN serves as the backbone for the NCs communications path. Contractor shall provide a FAC LAN as a dedicated LAN for the control system. LAN shall be IEEE 802.3 Ethernet over Fiber or Category 6 cable with switches and routers that support 1000base-T gigabit Ethernet throughput.
2. Device Level Network (DLN): Network used to connect PCUs and ASCs. These shall be Peer to Peer devices as defined in the BTL standard. Network speed shall be 78K bits per second.

C. Remote Data Access: The system shall support the Internet Browser-based remote access to the building data. The IAS contractor shall coordinate with the Owner's IT department to insure all remote browser access (if desired by the owner) is protected with the latest Niagara N4 Software updates and a VPN (Virtual Private Network) must be installed to protect the owner's network from cyber attacks.

D. Browser-based access: A remote/local user using a standard browser will be able access all control system facilities and graphics via the WAN or direct connection, with proper username and password. Only native Internet browser-based user interfaces (HTML5 , XML, CCS3, etc.) that do not require plug-ins (thin clients) are acceptable. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™, Firefox™ or Chrome™.

E. The communication speed between the controllers, LAN interface devices, CSS, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition.

F. BAS Control Systems Server (CSS): A server that maintains the systems configuration and programming database. It shall allow secure multiple-access to the control information.

G. Systems Configuration Database: The system architecture shall support maintaining the systems configuration database on a server that resides on the FAC LAN. User tools for DLN and FAC LAN management shall be provided and licensed to the Owner and shall allow unrestricted configuring, updating, maintaining, and expanding of all current devices, configurations and settings.

H. Database Schema shall be published and provided to the Owner to facilitate easy access to DLN and FAC LAN data.

2.1 BAS SERVER HARDWARE – Niagara 4 Site Supervisor shall be provided by BAS contractor and installed on BAS Server

A. Minimum Computer Configuration (Hardware Independent).

1. Central Server. Owner shall provide a dedicated BAS server with configuration that includes the following components as a minimum:
2. Processor: Intel Xeon CPU E5-2640 x64 (or better), compatible with dual- and quad-core processors.
3. Memory: 2 GB or more recommended for large systems, 8 GB or more recommended for the Windows 64-bit version.
4. Hard Drive: 256 GB minimum, more recommended depending on archiving requirements.
5. Display: Video card and monitor capable of displaying 1024 x 768 pixel resolution or greater.
6. Network Support: Ethernet adapter (10/100 Mb with RJ-45 connector).
7. Connectivity: Full-time high-speed ISP connection recommended for remote site access (i.e. T1, ADSL, cable modem).

B. Standard Client: The thin-client Web Browser BAS GUI shall be Microsoft Internet Explorer (10.0 or later) running on Microsoft 7+. No special software shall be required to be installed on the PCs used to access the BAS via a web browser.

2.2 SYSTEM NETWORK CONTROLLER (SNC) – Honeywell WEBs JACE 8000

A. These controllers are designed to manage communications between the Programmable IP Control Units (PICU), Programmable Plant Control Units (PPCU), Unitary IP Control Unit (UICU), Advanced Unitary Controllers (AUC), and BACnet Touchscreen Communication Thermostats (BCT) which are connected to its communications trunks or directly on the IP network, manage communications between itself and other system network controllers (SNC), PICUs, PPCUs, UICUs, and with any operator workstations (OWS) that are part of the BAS, and perform control and operating strategies for the system based on information from any controller connected to the BAS.

B. The controllers shall be fully programmable to meet the unique requirements of the facility it shall control.

C. The controllers shall be capable of peer-to-peer communications with other SNC's, PICUs, PPCUs, UICUs, and with any OWS connected to the BAS, whether the OWS is directly connected, connected via cellular modem or connected via the Internet.

D. The communication protocols utilized for peer-to-peer communications between SNC's will be Niagara 4 FoxS, BACnet TCP/IP and SNMP. Use of a proprietary communication protocol for peer-to-peer communications between SNC's is not allowed.

E. The SNC shall employ a device count capacity license model that supports expansion capabilities.

F. The SNC shall be enabled to support and shall be licensed with the following Open protocol drivers (client and server) by default:

1. BACnet
2. Lon
3. MODBUS
4. SNMP
5. KNX

G. The SNC shall be capable of executing application control programs to provide:

1. Calendar functions.
2. Scheduling.
3. Trending.
4. Alarm monitoring and routing.
5. Time synchronization.
6. Integration of LonWorks, BACnet, and MODBUS controller data.
7. Network management functions for all SNC, PICU, PPCU, UICU, AUC and BCT based devices.

H. The SNC shall provide the following hardware features as a minimum:

1. Two 10/100 Mbps Ethernet ports.
2. Two Isolated RS-485 ports with biasing switches.
3. 1 GB RAM
4. 4 GB Flash Total Storage / 2 GB User Storage
5. Wi-Fi (Client or WAP)
6. USB Flash Drive
7. High Speed Field Bus Expansion

8. -20-60 degrees C Ambient Operating Temperature
9. Integrated 24 VAC/DC Global Power Supply
10. MicroSD Memory Card Employing Encrypted Safe Boot Technology

I. The SNC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 16 simultaneous users.

J. The SNC shall provide alarm recognition, storage, routing, management and analysis to supplement distributed capabilities of equipment or application specific controllers.

K. The SNC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via cellular modem, or wide-area network.

L. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but not limited to:

1. Alarm.
2. Return to normal.
3. To default.

M. Alarms shall be annunciated in any of the following manners as defined by the user:

1. Screen message text.
2. Email of complete alarm message to multiple recipients.
3. Pagers via paging services that initiate a page on receipt of email message.
4. Graphics with flashing alarm object(s).

N. The following shall be recorded by the SNC for each alarm (at a minimum):

1. Time and date.
2. Equipment (air handler #, access way, etc.).
3. Acknowledge time, date, and user who issued acknowledgement.

O. Programming software and all controller "Setup Wizards" shall be embedded into the SNC.

P. The SNC shall support the following security functions.

1. Module code signing to verify the author of programming tool and confirm that the code has not been altered or corrupted.
2. Role-Based Access Control (RBAC) for managing user roles and permissions.
3. Require users to use strong credentials.
4. Data in Motion and Sensitive Data at Rest be encrypted.
5. LDAP and Kerberos integration of access management.
6. The SNC shall support the following data modeling structures to utilize Search; Hierarchy; Template; and Permission functionality:
7. Metadata: Descriptive tags to define the structure of properties.
8. Tagging: Process to apply metadata to components
9. Tag Dictionary

Q. The SNC shall employ template functionality. Templates are a containerized set of configured data tags, graphics, histories, alarms... that are set to be deployed as a unit based upon manufacturer's controller and relationships. All lower level communicating controllers (PICU, PPCU, UICU, AUC) shall have an associated template file for reuse on future project additions.

R. The SNC shall be provided with a 3 Year Software Maintenance license. Labor to implement not included.

2.3 CENTRAL PLANT AND AIR HANDLER APPLICATION CONTROLLERS

A. Provide one or more native BACnet application controllers for each air handler and provide native BACnet application controllers as needed for central plant control that adequately cover all objects listed in object list. All controllers shall interface to building controller through either MS/TP LAN using BACnet protocol, or Ethernet LAN using BACnet over Ethernet or BACnet TCP/IP. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of units. Controllers shall be fully programmable using graphical programming blocks. Programming tool shall be resident on operator workstation and be the same tool as used for the building controller. No auxiliary or non-BACnet controllers shall be used.

B. BACnet Conformance
1. Application controllers shall be approved by the BTL as meeting the BACnet Advanced Application Controller requirements.
2. Please refer to section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
3. Standard BACnet object types supported shall include, as a minimum, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Multi-state Values, Device, File, and Program object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

C. Application controllers shall include universal inputs with 12-bit resolution that accept 20K 0–5VDC, 4–20mA and dry contact signals. Any input on a controller may be either analog or digital with a minimum of three inputs that accept pulses. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller shall include binary and analog outputs on board. Analog outputs with 12-bit resolution shall support either 0–10VDC or 0–20mA. Binary outputs shall have LED indication of status. Software shall include scaling features for analog outputs. Application controller shall include 20VDC voltage supply for use as power supply to external sensors.
1. The position of each and every HOA switch shall be available system wide as a BACnet object property.

D. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller up to 20 times per second (minimum of 10 times per second) and capable of multiple PID loops for control of multiple devices. All calculations shall be completed using floating-point math and system shall support display of all information in floating-point nomenclature at operator's terminal.
1. The following control blocks shall be supported:
    a. Natural Log
    b. Exponential
    c. Log base 10
    d. X to the power of Y
    e. Nth square root of X
    f. 5th Order Polynomial Equations
    g. Astronomical Clock (sunrise/sunset calculation)

h. Time based schedules

E. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely using modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using programming tools as described in operator's terminal section.

F. Application controller shall include support for intelligent room sensor. Display on intelligent room sensor shall be programmable at application controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode, based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

G. Schedules
1. The controller shall support a minimum of 50 BACnet Schedule Objects and have a real time clock on board with battery backup to maintain time through a power loss.
2. Controller modules shall provide normal seven-day scheduling, holiday scheduling and event scheduling.

H. Logging Capabilities
1. Each controller shall log as minimum 50 trendlogs. Any object in the system (real or 5calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.
2. Logs may be viewed both on-site or off-site using WAN or remote communication.
3. Controller shall periodically upload trended data to networked operator's workstation for long-term archiving if desired.
4. Archived data stored in database format shall be available for use in third party spreadsheet or database programs.

I. Alarm Generation
1. Alarms may be generated within the system for any object change of value or state (either real or calculated). This includes things such as analog object value changes, binary object state changes, and various controller communication failures.
2. Each alarm may be dialed out as noted elsewhere.
3. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site using remote communications.
4. Controller must be able to handle up to 25 alarm setups stored as BACnet event enrollment objects, with system destination and actions individually configurable.

2.4 TERMINAL UNIT APPLICATION CONTROLLERS

A. Provide one native BACnet fully programmable field controller for each piece of unitary mechanical equipment that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller through MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of unit.

B. BACnet Conformance
1. Application controllers shall, as a minimum, support MS/TP BACnet LAN types. They shall communicate directly using this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a native BACnet device. Application controllers shall be approved by the BTL as meeting

the BACnet Application Specific Controller requirements and support all BACnet services necessary to provide the following BACnet functional groups:
   a. Files Functional Group
   b. Reinitialize Functional Group
   c. Device Communications Functional Group

2. Please refer to Section 22.2, BACnet Functional Groups in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
3. Standard BACnet object types supported shall include, as a minimum, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, and Program Object Types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
4. All field controllers shall be fully programmable.

C. Application controllers shall include universal inputs with 10-bit resolution that can accept 20K thermistors, 0–5VDC, 4–20mA, dry contact signals and a minimum of 3 pulse inputs. Any input on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor. Controller shall include binary outputs on board with analog outputs as needed.

D. All program sequences shall be stored on board controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely through modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using same programming tools as building controller and as described in operator workstation section. All programming tools shall be provided and installed as part of system.

2.5 ADVANCED UNITARY CONTROLLER (AUC) – Brand Name: Spyder Classic/Stryker/Spyder Model 5

A. The advanced unitary controller (AUC) platform shall be designed specifically to control HVAC - ventilation, filtration, heating, cooling, humidification, and distribution. Equipment includes constant volume air handlers, VAV air handlers, packaged RTU, heat pumps, unit vents, fan coils, natural convection units and radiant panels. The control shall use BACnet® based devices where the application has BTL Listed PICS defined. Where The controller platform shall provide options and advanced system functions, programmable and configurable, using Niagara 4 Framework™, that allow standard and customizable control solutions required in executing the "Sequence of Operation".

B. Minimum Requirements:

1. The controller shall be fully programmable or configurable with full functionality on any Niagara 4 brand platform.
   a. Support downloads to the controller in Niagara 4 platform.
   b. Support uploads from the controller to Niagara 4 platform.
   c. Support simulation/debug mode of the controller.

d. Maintain native GUI.
e. Native function-block programming software and all controller "Setup Wizards" shall be embedded within the Niagara 4 environment.

2. The AUC shall be capable of either integrating with other devices or stand-alone operation.
3. For VAV box applications, the AUC shall have an internal velocity pressure sensor.
   a. Sensor Type: Microbridge air flow sensor with dual integral restrictors.
   b. Operating Range: 0-to-1.5-inch H2O (0 to 374 Pa).
   c. Accuracy: +/- 2 % of full scale at 32 degrees to 122 degrees F (0 degrees to 50 degrees C); +/- 1 % of full scale at null pressure.
4. The AUC shall have two microprocessors. The Host processor contains on-chip FLASH program memory, FLASH information memory, and RAM to run the main HVAC application. The second processor for network communications. Controller memory minimum requirements include:
   a. FLASH Memory Capacity: 60 Kilobytes with 8 Kilobytes for application program.
   b. FLASH Memory settings retained for ten years.
   c. RAM: 2 Kilobytes.
5. The AUC shall have an internal time clock with the ability to automatically revert from a master time clock on failure.
   a. Operating Range: 24-hour, 365-day, multi-year calendar including day of week and configuration for automatic day-light savings time adjustment to occur on configured start and stop dates.
   b. Accuracy: +/- 1 minute per month at 77 degrees F (25 degrees C).
   c. Power Failure Backup: 24 hours at 32 degrees to 122 degrees F (0 degrees to 50 degrees C).
6. The AUC shall have Significant Event Notification, Periodic Update capability, and Failure Detect when network inputs fail to be detected within their configurable time frame.
7. The AUC shall have an internal DC power supply to power external sensors.
   a. Power Output: 20 VDC +/- 10 % at 75 mA.
8. The AUC shall have a visual indication (LED) of the status of the devise:
   a. Controller operating normally.
   b. Controller in process of download.
   c. Controller in manual mode under control of software tool.
   d. Controller lost its configuration.
   e. No power to controller, low voltage, or controller damage.
   f. Processor and/or controller are not operating.
9. The minimum AUC Environmental ratings.
   a. Operating Temperature Ambient Rating: -40 degrees to 150 degrees F (-40 degrees to 65.5 degrees C) for an AUC in unconditioned space.
   b. Storage Temperature Ambient Rating: -40 degrees to 150 degrees F (-40 degrees to 65.5 degrees C) for an AUC in unconditioned space.
   c. Operating Temperature Ambient Rating: 32 degrees to 122 degrees F (0 degrees to 50 degrees C) for an AUC in conditioned space.
   d. Storage Temperature Ambient Rating: 32 degrees to 122 degrees F (0 degrees to 50 degrees C) for an AUC in conditioned space.
   e. Relative Humidity: 5 % to 95 % non-condensing.
10. The AUC shall have the additional approval requirements, listings, and approvals:
    a. UL/cUL (E87741) listed under UL916 (Standard for Open Energy Management Equipment) with plenum rating.
    b. CSA (LR95329-3) Listed.
    c. Meets FCC Part 15, Subpart B, Class B (radiated emissions) requirements.
    d. Meets Canadian standard C108.8 (radiated emissions).
    e. Conforms requirements European Consortium standard EN 61000-6-1; 2001 (EU Immunity).

f. Conforms requirements European Consortium standard EN 61000-6-3; 2001 (EU Emission).

11. The AUC housing shall be UL plenum rated mounting to either a panel or DIN rail (standard EN50022; 7.5 mm x 35 mm).
12. For VAV box applications, the AUC shall provide an integrated actuator option.
    a. Actuator type: Series Floating.
    b. Rotation stroke: 95 degrees +/- 177; 3 degrees for CW or CCW opening dampers.
    c. Torque rating: 44 lb-inch (5 Nm).
    d. Run time for 90-degree rotation: 90 seconds at 60 Hz.
13. The AUC shall have a mix of Universal Inputs (UI), Digital Inputs (DI), Analog Outputs (AO), and Digital Triac Outputs (DO), as well as a 2-wire, polarity insensitive, AUC communication bus providing Sensor, Actuator, and I/O expandability.
    a. Analog outputs (AO) shall be capable of being configured as digital outputs (DO).
    b. Input and Output wiring terminal strips shall be removable from the controller without disconnecting wiring.
    c. Input and Output wiring terminals shall be designated with color coded labels.
    d. Universal inputs shall be capable of being configured as binary inputs, resistive inputs, voltage inputs (0-10 VDC), or current inputs (4-20 mA).
14. The AUC shall provide "continuous" automated loop tuning with an Adaptive Integral Algorithm Control Loop.
15. The AUC platform shall have standard HVAC application programs that are modifiable to support both the traditional and specialized "sequence of operations" as outlined in Section 4.
    a. Discharge air control and low limit.
    b. Pressure-dependent dual duct without flow mixing.
    c. Variable air volume with return flow tracking.
    d. Economizer with differential enthalpy.
    e. Minimum airflow coordinated with CO2.
    f. Unit ventilator cycle (1, 2, 3) 2-pipe.
    g. Unit ventilator cycle (1, 2, 3) 2-pipe with face/bypass.
    h. Unit ventilator cycle (1, 2, 3) 4-pipe.
    i. Unit ventilator cycle (1, 2, 3) 4-pipe with EOC valve.
    j. VAV terminal unit.
    k. VAV terminal unit fan speed control.
    l. Series fan.
    m. Parallel fan.
    n. Regulated air volume (room pressurization/de-pressurization).
    o. CV dual duct.
    p. Room CO2 control.
    q. Room Humidity.
    r. TOD occupancy sensor stand-by set points.

2.6 INPUT AND OUTPUT INTERFACE

A. General. Hard-wire input and output points to BCs, AACs, ASCs, or SAs.

B. Protection. Shorting an input or output point to itself, to another point, or to ground shall cause no controller damage. Input or output point contact with up to 24 V for any duration shall cause no controller damage.

C. Binary Inputs. Binary inputs shall monitor the on and off signal from a remote device. Binary inputs shall provide a wetting current of at least 12 mA and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.

D. Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shall accumulate up to 10 pulses per second.

E. Analog Inputs. Analog inputs shall monitor low-voltage (0-10 Vdc), current (4-20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

F. Binary Outputs. Binary outputs shall send an on-or-off signal for on and off control. Building Controller binary outputs shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.

G. Analog Outputs. Analog outputs shall send a modulating 0-10 Vdc or 4-20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.

H. Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.

I. Universal Inputs and Outputs. Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

2.7 POWER SUPPLIES AND LINE FILTERING

A. Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.
   a. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
   b. Line voltage units shall be UL recognized and CSA listed.

B. Power Line Filtering.

1. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:
   a. Dielectric strength of 1000 V minimum
   b. Response time of 10 nanoseconds or less
   c. Transverse mode noise attenuation of 65 dB or greater
   d. Common mode noise attenuation of 150 dB or greater at 40-100 Hz

2.7 OTHER CONTROL SYSTEM HARDWARE

A. Motorized control dampers that will not be integral to the equipment shall be furnished by the Control System Contractor. Control damper frames shall be constructed of galvanized steel, formed into changes and welded or riveted. Dampers shall be galvanized, with nylon bearings. Blade edge seals shall be vinyl. Blade edge and tip seals shall be included for all dampers. Blades shall be 16-gauge minimum and 6 inches wide maximum and frame shall be of welded channel iron. Damper leakage shall not exceed 10 CFM per square foot, at 1.5 inches water gauge static pressure.

1. Control damper actuators shall be furnished by the Control System Contractor. Two-position or proportional electric actuators shall be direct-mount type sized to provide a minimum of 5 in-lb torque per square foot of damper area. Damper actuators shall be spring return type. Operators shall be heavy-duty electronic type for positioning automatic dampers in response to a control signal. Motor shall be of sufficient size to operate damper positively and smoothly to obtain correct sequence as indicated. All applications requiring proportional operation shall utilize truly proportional electric actuators. Two-position actuators shall be provided with end switch.
2. Belimo acceptable actuator manufacturer

B. Control Valves: Control valves shall be 2-way or 3-way pattern as shown and constructed for tight shutoff at the pump shut-off head or steam relief valve pressure. Control valves shall operate satisfactorily against system pressures and differentials. Two-position valves shall be ' line' size. Proportional control valves shall be sized for a maximum pressure drop of 5.0 psi at rated flow (unless otherwise noted or scheduled on the drawings). Valves with sizes up to and including 2 inches (51 mm) shall be "screwed" configuration and 2-1/2 inches (63.5 mm) and larger valves shall be "flanged" configuration. All control valves, including terminal unit valves, less than 2 inches (51 mm) shall be globe valves. Electrically-actuated control valves shall include spring return type actuators sized for tight shut-off against system pressures (as specified above) and, when specified, shall be furnished with integral switches for indication of valve position (open-closed).

1. Control Valve Actuators: Actuators for terminal unit heating coils shall be "drive-open; drive-closed" type. All actuators shall have inherent current limiting motor protection. Valve actuators shall be 24-volt, electronic type, modulating or two-position as required for the correct operating sequence. Actuators on valves needing ' fail-safe' operation shall have spring return to Normal position. Modulating valves shall be positive positioning in response to the signal. All valve actuators shall be UL listed.
2. All control valves 2-1/2 inches (63.5 mm) or larger shall have position indication. All hot water control valves shall be Normally-Open arrangement; all chilled water control valves shall be Normally-Closed arrangement.
3. Belimo acceptable valve and actuator manufacturer

C. Wall Mount Room Temperature sensors: Each room temperature sensor shall provide temperature indication to the digital controller, provide the capability for a software-limited occupant set point adjustment (warmer-cooler slider bar or switch) and limited operation override capability. Room Temperature Sensors shall be 10,000-ohm thermistor type with a temperature range of -40 to 140 degrees F (-38 to 60 degrees C). The sensor shall be complete with a decorative cover and suitable for mounting over a standard electrical utility box. These devices shall have an accuracy of 0.5 degrees F (.024 degrees C) over the entire range.

1. Space Temperature Sensor Basis of Design – Honeywell TR40 – Blank Sensor
2. Spaces with Temperature/CO2/RH – Honeywell TR40-H-CO2 is basis of design

D. Duct-mounted and Outside Air Temperature Sensors: 10,000-ohm thermistor temperature sensors with an accuracy of 0.2 degrees C. Outside air sensors shall include an integral sun shield. Duct-mounted sensors shall have an insertion measuring probe of a length appropriate for the duct size, with a temperature range of -40 to 160 degrees F(-38 to 71 degrees C) The sensor shall include a utility box and a gasket to prevent air leakage and vibration noise. For all mixed air and preheat air applications, install bendable averaging duct sensors with a minimum 8 feet (2438 mm) long sensor element. These devices shall have accuracy of 0.5 degrees F (.024 degrees C) over the entire range.

E. Humidity sensors shall be thin-film capacitive type sensor with on-board nonvolatile memory, accuracy to plus or minus two percent (2%) at 0 to 90% RH, 12 - 30 VDC input voltage, analog output (0 - 10 VDC or 4 - 20mA output). Operating range shall be 0 to 100% RH and 32 to 140 degrees F (0 to 60 degrees C). Sensors shall be selected for wall, duct or outdoor type installation as appropriate.

F. Carbon Dioxide Sensors (CO2): Sensors shall utilize Non-dispersive infrared technology (N.D.I.R.), repeatable to plus or minus 20 PPM. Sensor range shall be 0 - 2000 PPM. Accuracy shall be plus or minus five percent (5%) or 75 PPM, whichever is greater. Response shall be less than one minute. Input voltage shall be 20 to 30 VAC or DC. Output shall be 0 - 10 VDC. Sensor shall be wall or duct mounted type, as appropriate for the application, housed in a high impact plastic enclosure.

G. Current Sensitive Switches: Solid state, split core current switch that operates when the current level (sensed by the internal current transformer) exceeds the adjustable trip point. Current switch to include an integral LED for indication of trip condition and a current level below trip set point.

H. Differential Analog (duct) Static Pressure Transmitters Provide a pressure transmitter with integral capacitance type sensing and solid-state circuitry. Accuracy shall be plus or minus 1% of full range; range shall be selected for the specific application. Provide zero and span adjustment capability. Device shall have integral static pickup tube.

I. Differential Air Pressure Switches: Provide SPDT type, UL-approved, and selected for the appropriate operating range where applied. Switches shall have adjustable setpoints and barbed pressure tips.

J. Water Flow Switches: Provide a SPST type contact switch with bronze paddle blade, sized for the actual pipe size at the location. If installed outdoors, provide a NEMA-4 enclosure. Flow switch shall be UL listed.

K. Temperature Control Panels: Furnish temperature control panels of code gauge steel with locking doors for mounting all devices as shown. All electrical devices within a control panel shall be factory wired. A complete set of ' as-built' control drawings (relating to the controls within that panel) shall be furnished within each control panel.

L. Pipe and Duct Temperature sensing elements: 10,000-ohm thermistor temperature sensors with and accuracy of ±1% accuracy. Their range shall be -5 to 250 degrees F (-20 to 121 degrees C). Limited range sensors shall be acceptable provided they are capable of sensing the range expected for the point at the specified accuracy. Thermal wells with heat conductive gel shall be included.

M. Low Air Temperature Sensors: Provide SPST type switch, with 15 to 55 degrees F (-9 to 13 degrees C), range, vapor-charged temperature sensor. Honeywell model L482A, or JCI approved equivalent.

N. Relays: Start/stop relay model shall provide either momentary or maintained switching action as appropriate for the motor being started. All relays shall be plugged in, interchangeable, mounted on a subbase and wired to numbered terminals strips. Relays installed in panels shall all be DPDT with indicating lamp. Relays installed outside of controlled devices shall be enclosed in a NEMA enclosure suitable for the location. Relays shall be labeled with UR symbol. RIB-style relays are acceptable for remote enable/disable.

O. Transducers: Differential pressure transducers shall be electronic with a 4-20 mA output signal compatible to the Direct Digital Controller. Wetted parts shall be stainless steel. Unit shall be designed to operate in the pressure ranges involved.

P. Control Power Transformers: Provide step-down transformers for all DDC controllers and devices as required. Transformers shall be sized for the load, but shall be sized for 50 watts, minimum. Transformers shall be UL listed Class 2 type, for 120 VAC/24 VAC operation.

Q. Water Detection Sensors:

2.8 WIRING AND RACEWAYS

A. General. Provide copper wiring, plenum cable, and raceways as specified in applicable sections of Division 26.

B. Insulated wire shall use copper conductors and shall be UL listed for 90°C (200°F) minimum service.

2.10 BAS SERVER & WEB BROWSER GUI - SYSTEM OVERVIEW

A. The BAS Contractor shall provide system software based on server/thin-client architecture, designed around the open standards of web technology. The BAS server shall communicate using Ethernet and TCP. Server shall be accessed using a web browser over Owner intranet and remotely over the Internet. BAS contract shall provide Niagara 4 Site Supervisor Software.

B. The intent of the thin-client architecture is to provide the operator(s) complete access to the BAS system via a web browser. The thin-client web browser Graphical User Interface (GUI) shall be browser and operating system agnostic, meaning it will support HTML5 enabled browsers without requiring proprietary operator interface and configuration programs or browser plug-ins. Microsoft, Firefox, and Chrome browsers (current released versions), and Windows as well as non-Window operating systems.

C. The BAS server software shall support at least the following server platforms (Windows 7, 8.1, Server 12). The BAS server software shall be developed and tested by the manufacturer of the system stand-alone controllers and network controllers/routers.

D. The web browser GUI shall provide a completely interactive user interface and shall provide a HTML5 experience that supports the following features as a minimum:

1. Trending.
2. Scheduling.
3. Electrical demand limiting.
4. Duty Cycling.
5. Downloading Memory to field devices.

6. Real time 'live' Graphic Programs.
7. Tree Navigation.
8. Parameter change of properties.
9. Set point adjustments.
10. Alarm / event information.
11. Configuration of operators.
12. Execution of global commands.

E. Add, delete, and modify graphics and displayed data.

F. Software Components: All software shall be the most current version. All software components of the BAS system software shall be provided and installed as part of this project. BAS software components shall include:

1. Server Software, Database and Web Browser Graphical User Interface.
2. 3 Year Software Maintenance license. Labor to implement not included.
3. Embedded System Configuration Utilities for future modifications to the system and controllers.
4. Embedded Graphical Programming Tools.
5. Embedded Direct Digital Control software.
6. Embedded Application Software.

G. BAS Server Database: The BAS server software shall utilize a Java Database Connectivity (JDBC) compatible database such as: MS SQL 8.0, Oracle 8i or IBM DB2. BAS systems written to Non -Standard and/or Proprietary databases are NOT acceptable.

H. Thin Client - Web Browser Based: The GUI shall be thin client or browser based and shall meet the following criteria:

I. Web Browser's for PC's: Only the current released browser (Explorer/Firefox/Chrome) will be required as the GUI and a valid connection to the server network. No installation of any custom software shall be required on the operator's GUI workstation/client. Connection shall be over an intranet or the Internet.

J. Secure Socket Layers: Communication between the Web Browser GUI and BAS server shall offer encryption using 128-bit encryption technology within Secure Socket Layers (SSL). Communication protocol shall be Hyper-Text Transfer Protocol (HTTP).

2.9 GRAPHICAL PROGRAMMING

A. The system software shall include a Graphic Programming Language (GPL) for all DDC control algorithms resident in all control modules. Any system that does not use a drag and drop method of graphical icon programming shall not be accepted. All systems shall use a GPL method used to create a sequence of operations by assembling graphic microblocks that represent each of the commands or functions necessary to complete a control sequence. Microblocks represent common logical control devices used in conventional control systems, such as relays, switches, high signal selectors etc., in addition to the more complex DDC and energy management strategies such as PID loops and optimum start. Each microblock shall be interactive and contain the programming necessary to execute the function of the device it represents.

B. Graphic programming shall be performed while on screen and using a mouse; each microblock shall be selected from a microblock library and assembled with other microblocks necessary to complete the specified sequence. Microblocks are then interconnected on screen using graphic "wires," each forming a logical connection. Once assembled, each logical grouping of microblocks and their interconnecting wires then forms a graphic function block which may be used to control any piece of equipment with a similar point configuration and sequence of operation.

C. Graphic Sequence: The clarity of the graphic sequence shall be such that the operator has the ability to verify that system programming meets the specifications, without having to learn or interpret a manufacturer's unique programming language. The graphic programming shall be self-documenting and provide the operator with an understandable and exact representation of each sequence of operation.

D. GPL Capabilities: The following is a minimum definition of the capabilities of the Graphic Programming software:

E. Function Block (FB): Shall be a collection of points, microblocks and wires which have been connected together for the specific purpose of controlling a piece of HVAC equipment or a single mechanical system.

F. Logical I/O: Input/Output points shall interface with the control modules in order to read various signals and/or values or to transmit signal or values to controlled devices.

G. Microblocks: Shall be software devices that are represented graphically and may be connected together to perform a specified sequence. A library of microblocks shall be submitted with the control contractors bid.

H. Wires: Shall be Graphical elements used to form logical connections between microblocks and between logical I/O.

I. Reference Labels: Labels shall be similar to wires in that they are used to form logical connections between two points. Labels shall form a connection by reference instead of a visual connection, i.e. two points labeled 'A' on a drawing are logically connected even though there is no wire between them.

J. Parameter: A parameter shall be a value that may be tied to the input of a microblock.

K. Properties: Dialog boxes shall appear after a microblock has been inserted which has editable parameters associated with it. Default parameter dialog boxes shall contain various editable and non-editable fields, and shall contain 'push buttons' for the purpose of selecting default parameter settings.

L. Icon: An icon shall be graphic representation of a software program. Each graphic microblock has an icon associated with it that graphically describes its function.

M. Menu-bar Icon: Shall be an icon that is displayed on the menu bar on the GPL screen, which represents its associated graphic microblock.

2.10 WEB BROWSER GRAPHICAL USER INTERFACE

A. Web Browser Navigation: The Thin Client web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed

to "feel" like a single application, and provide a complete and intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser to accomplish requirements of this specification. The Web Browser GUI shall (as a minimum) provide for navigation, and for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic set point controls, configuration menus for operator access, reports and reporting actions for events.

B. Login: On launching the web browser and selecting the appropriate domain name or IP address, the operator shall be presented with a login page that will require a login name and strong password. Navigation in the system shall be dependent on the operator's role-based application control privileges.

C. Navigation: Navigation through the GUI shall be accomplished by clicking on the appropriate level of a navigation tree (consisting of an expandable and collapsible tree control like Microsoft's Explorer program) and/or by selecting dynamic links to other system graphics. Both the navigation tree and action pane shall be displayed simultaneously, enabling the operator to select a specific system or equipment and view the corresponding graphic. The navigation tree shall as a minimum provide the following views: Geographic, Network, Groups and Configuration.

D. Geographic View shall display a logical geographic hierarchy of the system including: cities, sites, buildings, building systems, floors, equipment and objects.

E. Groups View shall display Scheduled Groups and custom reports.

F. Configuration View shall display all the configuration categories (Operators, Schedule, Event, Reporting and Roles).

G. Action Pane: The Action Pane shall provide several functional views for each subsystem specified. A functional view shall be accessed by clicking on the corresponding button:

H. Graphics: Using graphical format suitable for display in a web browser, graphics shall include aerial building/campus views, color building floor-plans, equipment drawings, active graphic set point controls, web content and other valid HTML elements. The data on each graphic page shall automatically refresh.

I. Dashboards: User customizable data using drag and drop HTML5 elements. Shall include Web Charts, Gauges, and other custom developed widgets for web browser. User shall have ability to save custom dashboards.

J. Search: User shall have multiple options for searching data based upon Tags. Associated equipment, real time data, Properties, and Trends shall be available in result.

K. Properties: Shall include graphic controls and text for the following: Locking or overriding objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the operator to depress an 'accept/cancel' button.

L. Schedules: Shall be used to create, modify/edit and view schedules based on the systems hierarchy (using the navigation tree).

M. Alarms: Shall be used to view alarm information geographically (using the navigation tree), acknowledge alarms, sort alarms by category, actions and verify reporting actions.

N. Charting: Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling. User shall have ability to create HTML charts through web browser without utilizing chart builder. User shall be able to drag and drop single or multiple data points, including schedules, and apply status colors for analysis.

O. Logic - Live Graphic Programs: Shall be used to display' live' graphic programs of the control algorithm, (micro block programming) for the mechanical/electrical system selected in the navigation tree.

P. Other actions such as Print, Help, Command, and Logout shall be available via a drop-down window.

Q. Color Graphics: The Web Browser GUI shall make extensive use of color in the graphic pane to communicate information related to set points and comfort. Animated .gifs or .jpg, vector scalable, active set point graphic controls shall be used to enhance usability. Graphics tools used to create Web Browser graphics shall be non-proprietary and conform to the following basic criteria:

R. Display Size: The GUI workstation software shall graphically display in a minimum of 1024 by 768 pixels 24 bit True Color.

S. General Graphic: General area maps shall show locations of controlled buildings in relation to local landmarks.

T. Color Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, as selected by Owner. Provide a visual display of temperature relative to their respective set points. The colors shall be updated dynamically as a zone's actual comfort condition changes.

U. Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability. .

V. Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:

1. Each piece of equipment monitored or controlled including each terminal unit.
2. Each building.
3. Each floor and zone controlled.

2.11 WEB BROWSER GRAPHICAL USER INTERFACE

A. Web Browser Navigation: The web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to "feel" like a single application, and provide a complete and intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser to accomplish requirements of this specification. The Web Browser GUI shall (as a

minimum) provide for navigation, and for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic setpoint controls, configuration menus for operator access, reports and reporting actions for events.

B. Login: On launching the web browser and selecting the appropriate domain name or IP address, the operator shall be presented with a login page that will require a login name and password. Navigation in the system shall be dependent on the operator's role privileges and geographic area of responsibility.

C. Navigation: Navigation through the GUI shall be accomplished by clicking on appropriate level of a navigation tree (consisting of expandable and collapsible tree control like Microsoft's Explorer program) and/or by selecting dynamic links to other system graphics. Both the navigation tree and action pane shall be displayed simultaneously, enabling the operator to select a specific system or equipment and view the corresponding graphic. The navigation tree shall as a minimum provide the following views: Geographic, Network, Groups and Configuration.

1. Geographic View shall display a logical geographic hierarchy of the system including: cities, sites, buildings, building systems, floors, equipment and objects.
2. Groups View shall display Scheduled Groups and custom reports.
3. Configuration View shall display all the configuration categories (Operators, Schedule, Event, Reporting and Roles).

D. Action Pane: The Action Pane shall provide several functional views for each HVAC or mechanical/electrical subsystem specified. A functional view shall be accessed by clicking on the corresponding button:

1. Graphics: Using graphical format suitable for display in a web browser, graphics shall include aerial building/campus views, color building floor-plans, equipment drawings, active graphic setpoint controls, web content and other valid HTML elements. The data on each graphic page shall automatically refresh.
2. Properties: Shall include graphic controls and text for the following: Locking or overriding objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the operator to depress an ' accept/cancel' button.
3. Schedules: Shall be used to create, modify/edit and view schedules based on the systems geographical hierarchy (using the navigation tree).
4. Alarms: Shall be used to view alarm information geographically (using the navigation tree), acknowledge alarms, sort alarms by category, actions and verify reporting actions.
5. Trends: Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling.
6. Logic - Live Graphic Programs: Shall be used to display' live' graphic programs of the control algorithm, (micro block programming) for the mechanical/electrical system selected in the navigation tree.
7. Other actions such as Print, Help, Command, and Logout shall be available via a drop-down window.

E. Color Graphics: The Web Browser GUI shall make extensive use of color in the graphic pane to communicate information related to set points and comfort. Animated .gifs or .jpg, vector scalable, active setpoint graphic controls shall be used to enhance usability. Graphics tools used to create Web Browser graphics shall be non-proprietary and conform to the following basic criteria:

1. Display Size: The GUI workstation software shall graphically display in a minimum of 1024 by 768 pixels 24 bit True Color.
2. General Graphic: General area maps shall show locations of controlled buildings in relation to local landmarks.

3. Color Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, as selected by Owner. Provide a visual display of temperature relative to their respective set points. The colors shall be updated dynamically as a zone's actual comfort condition changes.
4. Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability. .
5. Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:
   a. Each piece of equipment monitored or controlled including each terminal unit.
   b. Each building.
   c. Each floor and zone controlled.

F. Hierarchical Schedules: Utilizing the Navigation Tree displayed in the web browser GUI, an operator (with password access) shall be able to define a Normal, Holiday or Override schedule for an individual piece of equipment or room, or choose to apply a hierarchical schedule to the entire system, site or floor area. For example, Independence Day ' Holiday' for every level in the system would be created by clicking at the top of the geographic hierarchy defined in the Navigation Tree. No further operator intervention would be required and every control module in the system with would be automatically downloaded with the ' Independence Day' Holiday. All schedules that affect the system/area/equipment highlighted in the Navigation Tree shall be shown in a summary schedule table and graph.

1. Schedules: Schedules shall comply with the LonWorks and BACnet standards, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled based on:
   a. Types of schedule shall be Normal, Holiday or Override.
   b. A specific date,.
   c. A range of dates,.
   d. Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any).
   e. Wildcard (example, allow combinations like second Tuesday of every month).
2. Schedule Categories: The system shall allow operators to define and edit scheduling categories (different types of "things" to be scheduled; for example, lighting, HVAC occupancy, etc.). The categories shall include: name, description, icon (to display in the hierarchy tree when icon option is selected) and type of value to be scheduled.
3. Schedule Groups: In addition to hierarchical scheduling, operators shall be able to define functional Schedule Groups, comprised of an arbitrary group of areas/rooms/equipment scattered throughout the facility and site. For example, the operator shall be able to define an ' individual tenant' group - who may occupy different areas within a building or buildings. Schedules applied to the ' tenant group' shall automatically be downloaded to control modules affecting spaces occupied by the ' tenant group'.
4. Intelligent Scheduling: The control system shall be intelligent enough to automatically turn on any supporting equipment needed to control the environment in an occupied space. If the operator schedules an individual room in a VAV system for occupancy, for example, the control logic shall automatically turn on the VAV air handling unit, chiller, boiler and/or any other equipment required to maintain the specified comfort and environmental conditions within the room.
5. Partial Day Exceptions: Schedule events shall be able to accommodate a time range specified by the operator (ex: board meeting from 6 pm to 9 pm overrides Normal schedule for conference room).
6. Schedule Summary Graph: The schedule summary graph shall clearly show Normal versus Holiday versus Override Schedules and the net operating schedule that results

from all contributing schedules. Note: In case of priority conflict between schedules at the different geographic hierarchy, the schedule for the more detailed geographic level shall apply.

G. Alarms: Alarms associated with a specific system, area, or equipment selected in the Navigation Tree, shall be displayed in the Action Pane by selecting an ' Alarms' view. Alarms, and reporting actions shall have the following capabilities:

1. Alarms View: Each Alarm shall display an Alarms Category (using a different icon for each alarm category), date/time of occurrence, current status, alarm report and a bold URL link to the associated graphic for the selected system, area or equipment. The URL link shall indicate the system location, address and other pertinent information. An operator shall easily be able to sort events, edit event templates and categories, acknowledge or force a return to normal in the Events View as specified in this section.
2. Alarm Categories: The operator shall be able to create, edit or delete alarm categories such as HVAC, Maintenance, Fire, or Generator. An icon shall be associated with each alarm category, enabling the operator to easily sort through multiple events displayed.
3. Alarm Templates: Alarm template shall define different types of alarms and their associated properties. As a minimum, properties shall include a reference name, verbose description, severity of alarm, acknowledgement requirements, and high/low limit and out of range information.
4. Alarm Areas: Alarm Areas enable an operator to assign specific Alarm Categories to specific Alarm Reporting Actions. For example, it shall be possible for an operator to assign all HVAC Maintenance Alarm on the 1st floor of a building to email the technician responsible for maintenance. The Navigation Tree shall be used to setup Alarm Areas in the Graphic Pane.
5. Alarm Time/Date Stamp: All events shall be generated at the DDC control module level and comprise the Time/Date Stamp using the standalone control module time and date.
6. Alarm Configuration: Operators shall be able to define the type of Alarm generated per object. A ' network' view of the Navigation Tree shall expose all objects and their respective Alarm Configuration. Configuration shall include assignment of Alarm, type of Acknowledgement and notification for return to normal or fault status.
7. Alarm Summary Counter: The view of Alarm in the Graphic Pane shall provide a numeric counter, indicating how many Alarms are active (in alarm), require acknowledgement and total number of Alarms in the BAS Server database.
8. Alarm Auto-Deletion: Alarms that are acknowledged and closed shall be auto-deleted from the database and archived to a text file after an operator defined period.
9. Alarm Reporting Actions: Alarm Reporting Actions specified shall be automatically launched (under certain conditions) after an Alarm is received by the BAS server software. Operators shall be able to easily define these Reporting Actions using the Navigation Tree and Graphic Pane through the web browser GUI. Reporting Actions shall be as follows:
    a. Print: Alarm information shall be printed to the BAS server's PC or a networked printer.
    b. Email: Email shall be sent via any POP3-compatible e-mail server (most Internet Service Providers use POP3). Email messages may be copied to several email accounts. Note: Email reporting action shall also be used to support alphanumeric paging services, where email servers support pagers.
    c. File Write: The ASCII File write reporting action shall enable the operator to append operator defined alarm information to any alarm through a text file. The alarm information that is written to the file shall be completely definable by the operator. The operator may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).
    d. Write Property: The write property reporting action updates a property value in a hardware module.

e. SNMP: The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an alarm.
f. Run External Program: The Run External Program reporting action launches specified program in response to an event.

H. Trends: As system is engineered, all points shall be enabled to trend. Trends shall both be displayed and user configurable through the Web Browser GUI. Trends shall comprise analog, digital or calculated points simultaneously. A trend log's properties shall be editable using the Navigation Tree and Graphic Pane.

1. Viewing Trends: The operator shall have the ability to view trends by using the Navigation Tree and selecting a Trends button in the Graphic Pane. The system shall allow y- and x-axis maximum ranges to be specified and shall be able to simultaneously graphically display multiple trends per graph.
2. Local Trends: Trend data shall be collected locally by Multi-Equipment/Single Equipment general-purpose controllers, and periodically uploaded to the BAS server if historical trending is enabled for the object. Trend data, including run time hours and start time date shall be retained in non-volatile module memory. Systems that rely on a gateway/router to run trends are NOT acceptable.
3. Resolution. Sample intervals shall be as small as one second. Each trended point will have the ability to be trended at a different trend interval. When multiple points are selected for displays that have different trend intervals, the system will automatically scale the axis.
4. Dynamic Update. Trends shall be able to dynamically update at operator-defined intervals.
5. Zoom/Pan. It shall be possible to zoom-in on a particular section of a trend for more detailed examination and ' pan through' historical data by simply scrolling the mouse.
6. Numeric Value Display. It shall be possible to pick any sample on a trend and have the numerical value displayed.
7. Copy/Paste. The operator shall have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard keystrokes (i.e. CTRL+C, CTRL+V).
8. Trending data shall include the following features:
   a. Software that is capable of graphing the trend-logged object data shall be included.
   b. Access and ability to create, edit and view are restricted to users by user account credentials
   c. Specific and repeatable URL defines the trendlog(s) views for browser bookmarking and email compatibility.
   d. Call out of trendlog value at intersection of trend line and mouse-over vertical axis.
   e. Trendlog or Energy log and companion logs can be configured to display on one of two independent vertical scales embedded in the display.
   f. Click zoom for control of data set viewed along either graph axis.
   g. User-specifiable start and end dates as well as a fast scroll features that supports click zoom of macro scale view of the data for quickly finding data set based on visual signature.
   h. User export of the viewed data set to MS Excel.
   i. Web browser-based help.
   j. Optional min/max ranges (Upper Control Limits, Lower Control Limits) for each value.

I. Reports

1. AWS shall be capable of periodically producing reports of trendlogs, alarm history, tenant activities, device summary, energy logs, and override points. The frequency, content, and delivery are to be user adjustable.
2. All reports shall be capable of being delivered in multiple formats including text- and comma-separated value (CSV) files. The files can be printed, emailed, or saved to a folder, either on the server hard drive or on any network drive location.

J. Security Access: Systems that Security access from the web browser GUI to BAS server shall require a Login Name and Password. Access to different areas of the BAS system shall be defined in terms of Roles, Privileges and geographic area of responsibility as specified:

1. Roles: Roles shall reflect the actual roles of different types of operators. Each role shall comprise a set of ' easily understood English language' privileges. Roles shall be defined in terms of View, Edit and Function Privileges.
   a. View Privileges shall comprise: Navigation, Network, and Configuration Trees, Operators, Roles and Privileges, Alarm/Event Template and Reporting Action.
   b. Edit Privileges shall comprise: Setpoint, Tuning and Logic, Manual Override, and Point Assignment Parameters.
   c. Function Privileges shall comprise: Alarm/Event Acknowledgement, Control Module Memory Download, Upload, Schedules, Schedule Groups, Manual Commands, Print and Alarm/Event Maintenance.

2. Geographic Assignment of Roles: Roles shall be geographically assigned using a similar expandable/collapsible navigation tree. For example, it shall be possible to assign two HVAC Technicians with similar competencies (and the same operator defined HVAC Role) to different areas of the system.

K. Software

1. At the conclusion of the project, contractor shall leave with owner an electronic copy that includes the complete software operation system and project graphics, setpoints, system parameters, etc. This backup shall allow the owner to completely restore the system in the case of a computer malfunction.

2.12 ASHRAE 135 GATEWAYS

A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, Variable Refrigerant Flow, and variable-speed drives.

B. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specifically requested and approved by Owner.

C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.

D. Gateway Minimum Requirements:

1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.
2. Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.
3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.
4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs according to ASHRAE 135.

5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
6. Backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

2.13 UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS FOR WORKSTATIONS

A. 250 through 1000 VA:

1. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.
2. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.
    a. Larger-capacity units shall be provided for systems with larger connected loads.
3. Performance:
    a. Input Voltage: Single phase, 120- or 230-V ac, compatible with field power source.
    b. Load Power Factor Range (Crest Factor): 0.65 to 1.0.
    c. Output Voltage: 101- to 132-V ac, while input voltage varies between 89 and 152-V ac.
    d. On Battery Output Voltage: Sine wave.
    e. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
    f. Recharge time shall be a maximum of six hours to 90 percent capacity after full discharge to cutoff.
    g. Transfer Time: 6 ms.
    h. Surge Voltage Withstand Capacity: IEEE C62.41, Categories A and B; 6 kV/200 and 500 A; 100-kHz ringwave.
4. UPS shall be automatic during fault or overload conditions.
5. Unit with integral line-interactive, power condition topology to eliminate all power contaminants.
6. Include front panel with power switch and visual indication of power, battery, fault and temperature.
7. Unit shall include an audible alarm of faults and front panel silence feature.
8. Unit with four NEMA WD 1, NEMA WD 6 Configuration 5-15R receptacles.
9. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure).
10. Batteries shall be sealed lead-acid type and be maintenance free. Battery replacement shall be front accessible by user without dropping load.
11. Include tower models installed in ventilated cabinets to the particular installation location.

B. 1000 through 3000 VA:

1. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.
2. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.
    a. Larger-capacity units, or multiple units, shall be provided for systems with larger connected loads.
3. Performance:

a. Input Voltage: Single phase, 120-V ac, plus 20 to minus 30 percent.
b. Power Factor: Minimum 0.97 at full load.
c. Output Voltage: Single phase, 120-V ac, within 3 percent, steady state with rated output current of 10.0 A, 30.0-A peak.
d. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
e. Recharge time shall be a maximum of eight hours to 90 percent capacity.

4. UPS bypass shall be automatic during fault or overload conditions.
5. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure).
6. Batteries shall be sealed lead-acid type and be maintenance free.
7. Include tower models installed in ventilated cabinets or rack models installed on matching racks, as applicable to the particular installation location and space availability/configuration.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Thoroughly examine project plans for control device and equipment locations. Report discrepancies, conflicts, or omissions to Architect or Engineer for resolution before starting rough-in work.

B. Inspect site to verify that equipment can be installed as shown. Report discrepancies, conflicts, or omissions to Engineer for resolution before starting rough-in work.

C. Examine drawings and specifications for work of others. Report inadequate headroom or space conditions or other discrepancies to Engineer and obtain written instructions for changes necessary to accommodate Section 23 09 23 work with work of others. Controls Contractor shall perform at his expense necessary changes in specified work caused by failure or neglect to report discrepancies.

3.2 PROTECTION

A. The contractor shall protect all work and material from damage by his/her work or employees and shall be liable for all damage thus caused.

B. The contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The contractor shall protect any material that is not immediately installed. The contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.3 COORDINATION

A. Site.

1. Assist in coordinating space conditions to accommodate the work of each trade where work will be installed near or will interfere with work of other trades. If installation without coordination causes interference with work of other trades, Contractor shall correct conditions without extra charge.

2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.

B. Test and Balance.

1. Provide Test and Balance Contractor a single set of necessary tools to interface to control system for testing and balancing.
2. Train Test and Balance Contractor to use control system interface tools.
3. Provide a qualified technician to assist with testing and balancing the first 20 terminal units.
4. Test and Balance Contractor shall return tools undamaged and in working condition at completion of testing and balancing.

C. Life Safety.

1. Duct smoke detectors required for air handler shutdown are provided under Division 28. Interlock smoke detectors to air handlers for shutdown as specified in this Section Sequence of Operations.
2. Fire and smoke dampers and actuators required for fire-rated walls are provided under Division 23. Fire and smoke damper detector and control are provided under Division 28.

D. Coordination with Other Controls. Integrate with and coordinate controls and control devices furnished or installed by others as follows.

1. Communication media and equipment shall be provided as specified in this Section (Communication).
2. Each supplier of a controls product shall configure, program, start up, and test that product to meet the sequences of operation described in this Section regardless of where within the contract documents those products are described.
3. Coordinate and resolve incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.
4. Controls Contractor shall be responsible for integration of control products provided by multiple suppliers regardless of where integration is described within the contract documents.

3.4 PREPARATION

A. Clean surfaces thoroughly prior to installation.

B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.5 GENERAL WORKMANSHIP

A. Install system and materials in accordance with manufacturer's instructions, and as detailed on the project drawing set.

B. Line and low voltage electrical connections to control equipment shown specified or shown on the control diagrams shall be furnished and installed by the Control System Contractor in accordance with these specifications.

C. Equipment furnished by the Mechanical Contractor that is normally wired before installation shall be furnished completely wired. Control wiring normally performed in the field will be furnished and installed by the Control System Contractor.

D. All control devices mounted on the face of control panels shall be clearly identified as to function and system served with permanently engraved phenolic labels.

3.6 LOCATION AND INSTALLATION OF COMPONENTS

A. Locate and install equipment and components equipment in readily accessible locations as defined by Chapter 1 Article 100 Part A of the National Electrical Code (NEC).In general, mount 48 inches above floor with minimum 3 feet of clear access space in front of units. Obtain approval on locations from owner's representative prior to installation.

B. All instruments, switches, transmitters, etc., shall be suitably wired and mounted to protect them from vibration, moisture, and high or low temperatures.

C. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

D. Install equipment, piping, and wiring/raceway parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.

E. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

F. All equipment, installation, and wiring shall comply with industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

G. Identify all equipment and panels. Provide permanently mounted tags for all panels.

H. Provide stainless steel or brass thermowells suitable for respective application and for installation under other sections, and sized to suit pipe diameter without restricting flow.

3.7 FIELD QUALITY CONTROL

A. All work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances as identified in this Section.

B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship.

C. Contractor shall have work inspection by local and/or state authorities having jurisdiction over the work.

3.8 WIRING

A. Provide all interlock and control wiring. All wiring shall be installed neatly and professionally, in accordance with Specification Division 26 and all national, state and local electrical codes.

B. Provide wiring as required by functions as specified and as recommended by equipment manufacturers, to serve specified control functions. Provide shielded low capacitance wire for all communications trunks.

C. Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes as required. Coordinate location and arrangement of all control equipment with the owner's representative prior to rough-in.

D. Provide auxiliary pilot duty relays on motor starters as required for control function.

E. All control wiring in the utility room (mechanical, electrical, telephone and boiler rooms) and in wall to be installed in conduit. All wiring to be installed neatly and inconspicuously per local code requirements. If local code and the contract documents allows, control wiring above accessible ceiling spaces may be run with plenum-rated cable (without conduit).

F. Use manufacturer-specified wire for all network connections.

G. Use approved optical isolation and lightning protection when penetrating building envelope.

H. Read installation instructions carefully. Any unavoidable deviations shall be approved by owner's rep prior to installation.

3.9 COMMUNICATION WIRING

A. Communication wiring shall be low-voltage Class 2 wiring.

B. Install communication wiring in separate raceways and enclosures from other Class 2 wiring.

C. During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer.

D. Verify entire network's integrity following cable installation using appropriate tests for each cable.

E. Install lightning arrestor according to manufacturer's recommendations between cable and ground where a cable enters or exits a building.

F. Each run of communication wiring shall be a continuous length without splices when that length is commercially available. Runs longer than commercially available lengths shall have as few splices as possible using commercially available lengths.

G. Label communication wiring to indicate origination and destination.

H. Ground coaxial cable according to NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

I. BACnet MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:

1. The network shall use shielded, twisted-pair cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 100 pF per meter (30 pF per foot.)
2. The maximum length of an MS/TP segment is 1200 meters (4000 ft) with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
3. The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated by the use of repeaters.
4. An MS/TP EIA-485 network shall have no T connections.

3.10 FIBER OPTIC CABLE

A. During installation do not exceed maximum pulling tensions specified by cable manufacturer. Post-installation residual cable tension shall be within cable manufacturer's specifications.

B. Install cabling and associated components according to manufacturers' instructions. Do not exceed minimum cable and unjacketed fiber bend radii specified by cable manufacturer.

3.11 DDC OBJECT TYPE SUMMARY

A. Provide all database generation.

B. Displays

1. System displays shall show all analog and binary object types within the system. They shall be logically laid out for easy use by the owner. Provide outside air temperature indication on all system displays associated with economizer cycles.

C. Run Time Totalization

1. At a minimum, run time totalization shall be incorporated for each monitored major airflow fans and water flows. Warning limits for each point shall be entered for alarm and or maintenance purposes.

D. Trendlog

1. All binary and analog object types (including zones) shall have the capability to be automatically trended.

E. Alarm

1. All analog inputs (High/Low Limits) and selected binary input alarm points shall be prioritized and routed (locally or remotely) with alarm message per owner's requirements.

F. Database Save

1. Provide backup database for all standalone application controllers on disk.

3.12 FIELD SERVICES

A. Prepare and start logic control system under provisions of this section.

B. Start up and commission systems. Allow sufficient time for startup and commissioning prior to placing control systems in permanent operation.

C. Provide the capability for off-site monitoring at control contractor's local or main office. At a minimum, off-site facility shall be capable of system diagnostics and software download. Owner shall provide phone line for this service for one year or as specified.

3.13 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.

3.14 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to a force.

D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

F. Firestop penetrations made in fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Division 07 Section "Joint Sealants."

H. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

I. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

J. Corrosive Environments:

1. Avoid or limit use of materials in corrosive airstreams and environments, including, but not limited to, the following:
   a. Laboratory exhaust-air streams.
   b. Process exhaust-air streams.
2. When conduit is in contact with a corrosive airstream and environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment. Comply with requirements for

installation of raceways and boxes specified in Division 16 Section "Raceways and Boxes for Electrical Systems."

3. Where instruments are located in a corrosive airstream and are not corrosive resistant from manufacturer, field install products in NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.15 OPERATOR WORKSTATION INSTALLATION

A. Desktop Operator Workstations Installation:

1. Install operator workstation at location directed by Owner.
2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single duplex electrical power receptacle.
3. Install software on server and verify software functions properly.
4. Develop Project-specific graphics, trends, reports, logs and historical database.
5. Power workstation through a UPS unit. Locate UPS adjacent to workstation.

B. Color Graphics Application:

1. Develop Project-specific library of symbols for representing system equipment and products.
2. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
3. Refine graphics as necessary for Owner acceptance.
4. On receiving Owner acceptance, print a hard copy for inclusion in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

3.16 GATEWAY INSTALLATION

A. Install gateways if required for DDC system communication interface requirements indicated.

1. Install gateway required to suit indicated requirements.
2. Gateways connected to the Town-wide Network must be authorized, coordinated and approved by the Town of Fairfield IT Department.

B. Test gateway to verify that communication interface functions properly.

3.17 ROUTER INSTALLATION

A. Install routers if required for DDC system communication interface requirements indicated.

1. Install router(s) required to suit indicated requirements.
2. Routers connected to the Town-wide Network must be authorized, coordinated and approved by the Town of Fairfield IT Department.

B. Test router to verify that communication interface functions properly.

3.18 CONTROLLER INSTALLATION

A. Install controllers in enclosures to comply with indicated requirements.

B. Connect controllers to field power supply.

C. Install controller with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation Controllers:

1. Quantity and location of controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Top of controller shall be within 72 inches of finished floor.
4. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.19 ENCLOSURES INSTALLATION

A. Install the following items in enclosures, to comply with indicated requirements:

1. Gateways.
2. Routers.
3. Controllers.
4. Electrical power devices.
5. UPS units.
6. Relays.
7. Accessories.
8. Instruments.
9. Actuators

B. Attach wall-mounted enclosures to wall using the following types of steel struts:

1. For NEMA 250, Type 1 Enclosures: Use painted steel, galvanized-steel, or corrosion-resistant-coated steel strut and hardware.
2. For NEMA 250, Type 4 or Type 4X Enclosures and Enclosures Located Outdoors: Use stainless-steel strut and hardware.

C. Align top or bottom of adjacent enclosures of like size.

D. Install floor-mounted enclosures located in mechanical equipment rooms on concrete housekeeping pads. Attach enclosure legs using galvanized- or stainless-steel anchors.

E. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireway used for application shall have protection equal to NEMA 250 rating of connected enclosures.

3.20 INSTALLATION OF SENSORS

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequately for environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by wall framing.

D. All wires attached to sensors shall be sealed in their raceways or in the wall to stop air transmitted from other areas from affecting sensor readings.

E. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.

F. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 1 ft of sensing element for each 1 sqft of coil area.

G. Do not install temperature sensors within the vapor plume of a humidifier. If installing a sensor downstream of a humidifier, install it at least 10 ft downstream.

H. All pipe-mounted temperature sensors shall be installed in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

I. Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.

J. Differential Static Pressure.

1. Supply Duct Static Pressure. Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.
2. Return Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor.
3. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
4. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.
5. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shut-off valves installed before the tee.

K. Smoke detectors, freezestats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

3.21 FLOW SWITCH INSTALLATION

A. Use correct paddle for pipe diameter.

B. Adjust flow switch according to manufacturer's instructions.

3.22 ACTUATORS

A. General. Mount and link control damper actuators according to manufacturer's instructions.

1. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
3. Provide all mounting hardware and linkages for actuator installation.

B. Electric/Electronic

1. Dampers: Actuators shall be direct mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° travel available for tightening the damper seal. Actuators shall be mounted following manufacturer’s recommendations.
2. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

3.23 WARNING LABELS

A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the control system.

1. Labels shall use white lettering (12-point type or larger) on a red background.
2. Warning labels shall read as follows:

C A U T I O N
This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to"Off"position before servicing.

B. Permanent warning labels shall be affixed to all motor starters and control panels that are connected to multiple power sources utilizing separate disconnects.

1. Labels shall use white lettering (12-point type or larger) on a red background.
2. Warning labels shall read as follows.

C A U T I O N
This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

3.24 IDENTIFICATION OF HARDWARE AND WIRING

A. All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 2 in. of termination with control system address or termination number.

B. Permanently label or code each point of field terminal strips to show the instrument or item served.

C. Identify control panels with minimum 1 cm (½ in.) letters on laminated plastic nameplates.

D. Identify all other control components with permanent labels. All plug-in components shall be labeled such that label removal of the component does not remove the label.

E. Identify room sensors related to terminal boxes or valves with nameplates.

F. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

G. Identifiers shall match record documents.

3.25 CONTROL SYSTEM CHECKOUT AND TESTING

A. Startup Testing. Complete startup testing to verify operational control system before notifying Owner of system demonstration. Provide Owner with schedule for startup testing. Owner may have representative present during any or all startup testing.

1. Calibrate and prepare for service each instrument, control, and accessory equipment furnished under this Section.
2. Verify that all control wiring is properly connected and free of shorts and ground faults. Verify that terminations are tight.
3. Enable control systems and verify each input device's calibration. Calibrate each device according to manufacturer's recommendations.
4. Verify that all binary output devices such as relays, solenoid valves, two-position actuators and control valves, and magnetic starters, operate properly and that normal positions are correct.
5. Verify that all analog output devices such as I/Ps and actuators are functional, that start and span are correct, and that direction and normal positions are correct. Check control valves and automatic dampers to ensure proper action and closure. Make necessary adjustments to valve stem and damper blade travel.
6. Prepare a log documenting startup testing of each input and output device, with technician's initials certifying each device has been tested and calibrated.
7. Verify that system operates according to sequences of operation. Simulate and observe each operational mode by overriding and varying inputs and schedules. Tune PID loops and each control routine that requires tuning.
8. Alarms and Interlocks.
    a. Check each alarm with an appropriate signal at a value that will trip the alarm.
    b. Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction.
    c. Test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.

3.26 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration. Prior to acceptance, perform the following performance tests to demonstrate system operation and compliance with specification after and in addition to tests specified in Article 3.27 (Control System Checkout and Testing). Provide Engineer with log documenting completion of startup tests.

1. Commissioning agent will be present to observe and review system demonstration. Notify Commissioning agent at least 10 days before system demonstration begins.
2. Demonstration shall follow process submitted and approved. Complete approved checklists and forms for each system as part of system demonstration.

3. Demonstrate actual field operation of each sequence of operation as specified in Part IV of this Section. Provide at least two persons equipped with two-way communication. Demonstrate calibration and response of any input and output points requested by Engineer. Provide and operate test equipment required to prove proper system operation.
4. Demonstrate compliance with System Performance section.
5. Demonstrate compliance with sequences of operation through each operational mode.
6. Demonstrate complete operation of operator interface.
7. Demonstrate each of the following:
    a. DDC loop response. Supply graphical trend data output showing each DDC loop's response to a setpoint change representing an actuator position change of at least 25% of full range. Trend sampling rate shall be from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show setpoint, actuator position, and controlled variable values. Engineer will require further tuning of each loop that displays unreasonably under- or over-damped control.
    b. Demand limiting. Supply trend data output showing demand-limiting algorithm action. Trend data shall document action sampled each minute over at least a 30-minute period and shall show building kW, demand-limiting setpoint, and status of setpoints and other affected equipment parameters.
    c. Building fire alarm system interface.
    d. Trend logs for each system. Trend data shall indicate setpoints, operating points, valve positions, and other data as specified in the points list provided with each sequence of operation in Section 23 09 93. Each log shall cover three 48-hour periods and shall have a sample frequency not less than 10 minutes or as specified on its points list. Logs shall be accessible through system's operator interface and shall be retrievable for use in other software programs as specified in Section 23 09 23 (Trend Configuration).
8. Tests that fail to demonstrate proper system operation shall be repeated after Contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.

B. Acceptance.

1. After tests described in this specification are performed to the satisfaction of both Commissioning agent and Owner, commissioning agent will accept control system as meeting completion requirements. Commissioning agent may exempt tests from completion requirements that cannot be performed due to circumstances beyond Contractor's control. Commissioning agent will provide written statement of each exempted test. Exempted tests shall be performed as part of warranty.
2. System shall not be accepted until completed demonstration forms and checklists are submitted and approved as required in this Section.

3.27 FOLLOW UP SERVICES

A. Occupancy Adjustments After Each Phase: When requested within 12 months of date of Substantial Completion, of each phase, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three (3) visits to Project during other than normal occupancy hours for this purpose.

B. Occupancy Adjustments After Final Phase: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to six (6) visits to Project during other than normal occupancy hours for this purpose.

3.28 CLEANING

A. Each day clean up debris resulting from work. Remove packaging material as soon as its contents have been removed. Collect waste and place in designated location.

B. On completion of work in each area, clean work debris and equipment. Keep areas free from dust, dirt, and debris.

C. On completion of work, check equipment furnished under this section for paint damage. Repair damaged factory-finished paint to match adjacent areas. Replace deformed cabinets and enclosures with new material and repaint to match adjacent areas.

3.29 TRAINING

A. Meet all applicable Training requirements of Division 1, Division 23, and the following.

B. The Controls contractor shall provide four (4) copies of training manual describing all operating and routine maintenance service procedures. The duration of the training classes shall be no less than twenty four (24) hours of multiple sessions. The training sessions are to be conducted during normal working hours. The training sessions shall consist of both hands-on and classroom training at the job site.

C. Provide training for designated staff of Owner's representatives. Training shall be provided via self-paced training, web-based or computer-based training, off-site classroom training, on-site training and a combination of training methods.

D. Trainers - Persons conducting the training shall be knowledgeable in the workings of the system, and shall be regularly engaged in training exercises, so as to provide effective training. Acceptability of the trainers shall be at the discretion of the Owner.

E. Training Classes - Prior to conducting training, prepare and submit the proposed training literature, scope and topics to the Commissioning Authority for review and approval. Submit this information at least four (4) weeks prior to the first training class.

F. Training shall enable students to accomplish, at a minimum, the following objectives.

1. Proficiently operate system
2. Understand control system architecture and configuration
3. Understand DDC system components
4. Understand system operation, including DDC system control and optimizing routines (algorithms)
5. Operate workstation and peripherals
6. Log on and off system
7. Access graphics, point reports, and logs
8. Adjust and change system setpoints, time schedules, and holiday schedules
9. Recognize common HVAC system malfunctions by observing system graphics, trend graphs, and other system tools
10. Understand system drawings and Operation and Maintenance manual
11. Understand job layout and location of control components
12. Access data from DDC controllers
13. Operate portable operator's terminals
14. Create and change system graphics

15. Create, delete, and modify alarms, including configuring alarm reactions
16. Create, delete, and modify point trend logs (graphs) and multi-point trend graphs
17. Configure and run reports
18. Add, remove, and modify system's physical points
19. Create, modify, and delete application programming
20. Add operator interface stations
21. Add a new controller to system
22. Download firmware and advanced applications programming to a controller
23. Configure and calibrate I/O points
24. Maintain software and prepare backups
25. Interface with job-specific, third-party operator software
26. Add new users and understand password security procedures

G. Provide approved training manuals to the Owner at least one week prior to the first class, one copy per student.

1. In addition to Commissioning Authority’s approved training literature, training manuals shall also include the following:
   a. Manufacturer’s training brochures.
   b. Operation and maintenance manuals.
   c. Completed Field Acceptance Test Procedure.
   d. “As-installed” Drawings.
   e. Manufacturer’s Operation Manuals.
   f. Software interaction sheets to be used in instructing students how to use the control system, on a command-by-command basis.

H. Perform classroom training using a network of working controllers representative of installed hardware.

END OF SECTION 230923

SECTION 230993 – SEQUENCE OF OPERATION FOR HVAC CONTROLS

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 control sequences for HVAC systems, subsystems and equipment.

B. Related Sections include the following:
   1. Section 230900 "Instrumentation and Control for HVAC" for control equipment and devices and for submittal requirements.

1.3 GENERAL

A. Unless noted otherwise herein, all control functions described in this sequence of operation shall be accomplished by the Building Automation System (BAS), and all equipment shall be started, stopped and positioned (if a modulating device) by the BAS. All hardware necessary to accomplish the control functions shall be provided by the ATC contractor, unless noted otherwise. The ATC contractor shall coordinate the quantity of required final drive devices (damper motors, control valves, etc.) and sensors with the mechanical equipment vendor's products.

B. All setpoints described in this sequence of operation shall be fully adjustable throughout the entire range of the sensors being used to measure the variable being controlled. All controlled variables identified in the following sequence of operation shall be maintained at setpoint using proportional-integral control algorithms, in order to ensure that no error exists between the controlled variable and its setpoint at steady-state conditions. Proportional-integral-derivative algorithms shall be used if the process so warrants, at the discretion of the control software programmer.

C. A unique schedule shall be provided for each piece of equipment controlled by the BAS. Applying a single schedule to multiple pieces of equipment is not permissible.

D. Point Lists, if provided in the Sequence, are a Minimum and should be used as a guideline. All points listed are required. Any additional points required to meet the sequence of operations or the specification or the intent of the specification will be included.

E. Alarms will be set up initially by the ATC contractor.
   1. The following alarm shall be generated for all systems:
      a. High humidity alarm
      b. High condensate drain alarm
      c. Condensate overflow Unit Shutdown
      d. Additional alarm shall be coordinated with manufacturer for factory provided controllers.

2. The following alarm shall be generated and sent to at least two (2) remote locations. Remote locations shall be coordinated with the Owner.
   a. Kennel, Quarantine and Cattery space temperature alarm:
      1) When space temperature rises above 85 degrees F (adj).
      2) When space temperature drops below 50 degrees F (adj).

3. The system will be capable of unlimited alarms, but the selected alarms will not be the left for the customer to set. Any alarms that the customer requests to be set up will be done by the ATC Contractor at no additional charge.

F. Trending. At a minimum, all points of physical control shall be trended and stored for a minimum of one (1) year. Digital points shall be trended on change of value. Analog points shall be trended in 15-minute intervals.

G. ATC Contractor shall provide BAS interface with factory provided BacNet Controls, where equipped.

H. ATC Contractor shall provide all necessary points and sensors for monitoring and controlling the sequence of operations in addition to factory provided sensors.

I. ATC contractor shall be responsible for the installation and communication wiring of components to provide a complete and operational system.

1.4 KENNEL SYSTEM (ERV-1, AHU-1 and ASHP-1)

A. General
1. Kennel system shall consist of an Energy Recovery Ventilator (ERV), Air Handing Unit (AHU) and an Air Source Heat Pump Unit (ASHP)
2. The ERV shall provide 100% tempered outside air to the air handling unit. The ERV shall be provided with complete controls from the unit manufacturer. All BACnet data available from the factory controller shall be interfaced with the BMS. ERV operation is based on specified manufacturer's standard sequence of operation and is included for reference. Other acceptable manufacturers shall follow their own sequence of operation.
3. The AHU-1 shall have a factory provided controller and shall be interfaced with the BAS.
4. The system shall operate providing system safeties are satisfied.

B. ERV-1 Operation
1. ERV-1 shall run whenever AHU-1 runs.
2. ERV-1 shall run based on factory programmed sequence of operation.
3. ERV Unit Start Command
4. An input signal is required to enable the unit operation. The unit will be commanded on by:
   1) Digital input
   2) BAS command
   b. All types of input that are enabled must be true before the unit starts.
      1) The exhaust fan starts after a 3 second delay (adjustable). The exhaust fan will not start until the damper actuator end switch closes.
      2) The supply fan starts after a 6 second delay (adjustable). The supply fan will not start until the damper actuator end switch closes.
      3) The supply fan, exhaust fan, [economizer], [heating] are controlled based on the chosen unit operating modes and air conditions.
5. ERV Unit Stop Command
   a. The unit can then be commanded off by:
      1) Digital Input

2) BAS command

b. Supply fan and exhaust fan are de-energized.

c. All dampers are unpowered and spring return to their default position after a 10 second delay (adjustable).

6. Supply Fan Operation
   a. The supply fan shall operate at a constant speed.
   b. The unit will attempt to start the supply fan when the supply fan delay timer expires. When the supply fan starts the supply fan adjustable current switch should close and remain closed until the fan is turned off.
7. Supply Fan Status
   a. Once the supply fan current switch closes [heating] operation is allowed. After a delay of 90 seconds (adjustable) from supply fan start signal, if the supply fan current switch is still open the supply fan alarm should be set to true and [heating] operation shall be prohibited. The supply fan status shall be set to true only when the supply fan output is on, and supply fan current switch is closed. The supply fan status shall be false in all other circumstances.
8. Supply Air Flow Control
   a. The controller will adjust the supply fan ECM command to maintain the supply air flow rate at a set point. The supply air flow rate set point is entered and adjusted from the unit controller display [or provided by the BMS]. The minimum and maximum values for supply air flow rate set point are unit dependent. An adjustable PI (proportional & integral) loop will compare the measured supply air flow to the air flow rate set point and adjust the fan speed. If the measured supply air flow rate varies from the desired air flow rate by more than 10% (adjustable) for more than 60 seconds (adjustable) a supply air flow rate alarm will be set to true. This supply fan operation mode can be used to provide a constant supply air flow rate as the unit filters become loaded.
9. Exhaust Fan Operation
   a. The exhaust fan will operate at a constant speed.
   b. The unit will attempt to start the exhaust fan when the exhaust fan delay timer expires. When the exhaust fan starts the exhaust fan adjustable current switch should close and remain closed until the fan is turned off.
10. Exhaust Fan Status
    a. After a delay of 90 seconds (adjustable) from exhaust fan start signal, if exhaust fan current switch is still open the exhaust fan alarm should be set to true. The exhaust fan status shall be set to true only when the exhaust fan output is on and exhaust fan current switch is closed. The exhaust fan status shall be false in all other circumstances.
11. Exhaust Air Flow Control
    a. The controller will adjust the exhaust fan ECM command to maintain the exhaust air flow rate at a set point. The exhaust air flow rate set point is entered and adjusted from the unit controller display [or provided by the BMS]. The minimum and maximum values for the exhaust air flow rate set point are unit dependent. An adjustable PI (proportional & integral) loop will compare the measured exhaust air flow to the air flow rate set point and adjust the fan speed. If the measured exhaust air flow rate varies from the desired air flow rate by more than 10% (adjustable) for more than 60 seconds (adjustable) an exhaust air flow rate alarm will be set to true. This exhaust fan operation mode can be used to provide a constant exhaust air flow rate as the unit filters become loaded.
12. Economizer (Bypass) Operation
    a. During normal operation the bypass damper shall remain closed and the face damper open to allow full energy recovery. During economizer operation the bypass damper will be open and the face damper will close to bypass the core. The economizer state can be controlled by enthalpy.
       1) The economizer will be locked out when:

2) The outside air enthalpy is greater than return air enthalpy.
3) The outside air temperature is less than the economizer field adjustable low lockout.

C. AHU-1 and ASHP-1 Operation

1. The AHU-1 and ASHP-1 shall be indexed for Occupied and Unoccupied modes by the BAS
2. Mode Enable Sensor Options
   a. The temperature of the space temperature sensor will determine whether the unit is in heating, cooling or vent mode during occupied operation.
3. Occupied Mode Initiation
   a. BACnet command
   b. Pushbutton Override button on a Space Sensor (Override length is user adjustable).

4. Unoccupied Operation
   a. If a space temperature sensor and/or an indoor humidity sensor are installed, the unit can use the Night Setback Offsets (applied to the Mode Enable Setpoints) for heating and cooling calls and the normal Dehumidification Setpoint (no offset) for dehumidification calls.
   b. If there is no call for Heating or Cooling, or if Night Setback operation has not been configured, the unit will be Off.
5. HVAC Modes of Operation
   a. Cooling Mode
   b. Heating Mode
   c. Vent Mode
   d. Dehumidification Mode
   e. Off Mode
6. Cooling Mode with Variable Capacity Compressor
   a. Cooling is enabled when the temperature at the Mode Enable Sensor rises one deadband above the Cooling Setpoint. Cooling is disabled when the Mode Enable temperature falls one deadband below the Cooling Setpoint. The setpoint and deadband are user adjustable.
   b. In the cooling mode, as the Supply Air Temperature (SAT) rises above the Active Supply Air Cooling Setpoint (see Supply Air Temperature Setpoint Reset section for explanation), compressors will modulate and stage based on the unit configuration in order to control to the Active Supply Air Cooling Setpoint.
   c. Each stage must meet its Minimum Off Time (adj.) before it is allowed to energize and successive stages can energize if the SAT rises above the Active Supply Air Cooling Setpoint for the Cooling Stage Up Delay period (adj).
   d. For compressors to stage down Minimum Run Times (adj.) must be satisfied, and the SAT needs to be below the Active Supply Air Cooling Setpoint minus the Cooling Stage Control for a period of time equal to the Stage Down Delay.
   e. Mechanical cooling is disabled if the Outdoor Air Temperature (OAT) falls 1° below the Cooling Lockout Setpoint and will remain disabled until the OAT rises 1° above the Cooling Lockout Setpoint. If the OAT disables mechanical cooling while it is currently operating, mechanical cooling will stage off as minimum run times and stage down delays are satisfied.
7. Heating Mode
   a. Heating is enabled when the temperature at the Mode Enable Sensor falls one deadband below the Heating Setpoint. Heating is disabled when the Mode Enable temperature rises one deadband above the Heating Setpoint.
   b. In the Heating Mode, as the Supply Air Temperature falls below the Active Supply Air Heating Setpoint (see Supply Air Temperature Setpoint Reset section for explanation), the heating will begin to stage on or to modulate. Each stage must

meet its Minimum Off Time (adj.) before it is allowed to energize and successive stages are subject to a Heating Stage Up Delay (adj).

c. Heating stages will continue to run until the supply air temperature rises above the Active Supply Air Temperature Setpoint plus the Heating Stage Control Window at which point the heating will begin to stage off. Each stage must meet its Minimum Run Time (adj.) before it is allowed to stage off, and successive stages are subject to a Heating Stage Down Delay (adj.).

d. Mechanical heating is disabled if the Outdoor Air Temperature (OAT) rises 1° above the Heating Lockout Setpoint and will remain disabled until the OAT falls 1° below the Heating Lockout Setpoint. If the OAT disables mechanical heating while it is currently operating, mechanical heating will stage off as minimum run times and stage down delays are satisfied.

8. Primary and Secondary Heating
   a. The Primary Heat shall be the Heat pump
   b. Secondary Heat would be a staged SCR Electric.
   c. If the Primary Heat modulates to 100%, Secondary Heat will then be allowed to stage on, while the Primary Heat is allowed to modulate between the stages as they stage up and down as needed to maintain the Heating Supply Air Setpoint.
   d. When outside air temperature drops below 10 deg F (adj), the primary heat will be off and the secondary heat shall be allowed to stage on.
9. Dehumidification Mode
   a. Dehumidification can be initiated anytime in the Occupied or Unoccupied Mode during Cooling, Heating, Vent, or Off Mode. This can create a Cooling Dehumidification Mode, a Heating Dehumidification Mode.
   b. Dehumidification is enabled when the Indoor Humidity rises above the Indoor Humidity Enable/Hi Reset Setpoint and is disabled when the Indoor Humidity falls below the Disable/Lo Reset Setpoint and requires the use of the E-BUS Combination Space (or Return Air) Temperature/Humidity Sensor.
   c. Dehumidification shall be selected as a priority mode and is then active anytime the humidity is above the Setpoint.
   d. Once in dehumidification, the unit will modulate the compressor in order maintain the Evaporator Coil Suction (Saturation) Temperature at the Coil Suction (Saturation) Temperature Setpoint.
   e. A coil suction pressure sensor is required and is typically factory installed.
   f. Modulating dehumidification Reheat is always controlled to the appropriate Active Supply Air Temperature Setpoint which will be dependent on whether you are in Cooling Dehumidification, Heating Dehumidification, or Vent Dehumidification. During Vent Mode Dehumidification the Supply Air Temperature Setpoint is calculated to be halfway between the HVAC Mode Setpoints.
10. Ventilation Mode
   a. This mode is only available in the Occupied Mode of operation on units configured for continuous supply fan operation and is generated anytime there is no demand for heating or cooling.
11. Air to Air Heat Pump Operation
   a. Cooling Mode will operate in the same manner as described in the Cooling section.
   b. A reversing valve relay output can be configured to activate with the first compressor stage in the Heating Mode or the Cooling Mode of operation.
   c. In the Heating Mode, Compressor Heat, Auxiliary Heat, and Emergency Heat can be used to achieve the Active Supply Air Temperature (SAT) Heating Setpoint. Auxiliary heat can be used in conjunction with compressor heat. Emergency heat can only be used if the compressors are locked out.
   d. Auxiliary Heat can be either a modulating or staged form of heat, or it can be a modulating form of heat followed by staged heat. Emergency heat can only be staged.
   e. Auxiliary Heat will only be enabled (after a stage up delay) when compressor heat has fully staged up and/or modulated to 100% and it still cannot maintain the

Heating Supply Air Setpoint. Any modulating compressor heat will be locked at 100% until the SAT rises above the SAT Heating Setpoint plus the Heating Stage Window. At that point, the Auxiliary Heat will stage off (after a stage down delay) and modulating compressor(s) heat will again be allowed to modulate.

f. When the Outdoor Air Temperature (OAT) is below the Heating Lockout but above the OAT Compressor Heating Lockout, Compressor Heat will be used and can be supplemented by Auxiliary Heat.

g. When the OAT is below the OAT Compressor Heating Lockout, Compressor Heat is locked out. Auxiliary Heat will then be the primary heat and can be supplemented with stage(s) of Emergency Heat (if available). Emergency heat is only available when the OAT is below the OAT Compressor Lockout.

12. Heat Pump Standard Defrost Operation
    a. If the compressor(s) are operating in the Heating Mode and the Defrost Coil Temperature Switch closes, the unit will enter the Defrost Mode, provided the user-adjustable Defrost Interval Timer has elapsed since the last Defrost Cycle.
    b. In the Defrost Cycle, the reversing valve signal is switched to the opposite operation, and the compressors are brought to maximum capacity. Auxiliary Heat will be used to attempt to maintain the Heating SAT Setpoint.
    c. The unit will leave the Defrost Mode after 10 minutes have elapsed or the Defrost Coil Temperature Switch opens - whichever happens first.
    d. If the unit leaves the compressor heating mode, the Defrost Interval timer will restart once the unit re-enters the compressor heating mode.
13. Space Sensor Operation
    a. Sensor with Override and Setpoint Slide Adjust.
    b. Sensors with Setpoint Slide Adjust can be programmed to allow space setpoint adjustment of up to +/- 10° F.
    c. The Slide Adjust can adjust the setpoint of whichever temperature sensor is configured as the controlling sensor, even if it is not the installed Space Sensor. If Space Temperature is the SAT/Reset Source, then the Slide Adjust will adjust the HVAC Mode Enable setpoints and the SAT/Reset Source setpoints simultaneously.
    d. During Unoccupied hours the Override Button can be used to force the unit back into the Occupied Mode (by pressing the button for less than 3 seconds) for a user-defined override duration of up to 8.0 hours. Pressing the button between 3 and 10 seconds cancels the override.
14. Supply Fan Operation
    a. Occupied Mode – Supply fan shall be configured to run continuously.
    b. Unoccupied Mode – Supply fan shall cycle on a call for heating, cooling or dehumidification.
    c. Anytime the Supply Fan is requested to start, a 1 minute minimum off timer must be satisfied. If the timer is satisfied the Supply Fan relay is activated while all other outputs are held off for a period of 1-2 minutes to purge stagnate air from the ductwork before heating or cooling occurs.
    d. In fan cycle mode or when going unoccupied the supply fan is held on for 2 minutes after the last stage of heating or cooling stages off.
15. Head Pressure Control
    a. The factory provided controller shall monitor head pressure transducers and control multiple fans or valves to maintain the head pressure setpoint.
    b. Different head pressure setpoints shall be used for Cooling Mode and Dehumidification Reheat Mode
    c. Modulating condenser signal is always 100% during heat pump Heating Mode.
16. Supply Air Temperature Setpoint Reset
    a. Reset the Supply Air Temperature (SAT) Setpoint based on space temperature.
    b. A High and a Low Reset Source Setpoint shall be configured that will correspond to configured Low and High SAT Setpoints. This must be done separately for the Cooling Mode setpoints and for the Heating Mode setpoints.

c. When the Reset Source is at its highest configured setpoint the SAT Setpoint will be reset to its lowest configured setpoint. When the Reset Source is at its lowest configured setpoint the SAT Setpoint will be reset to its highest configured setpoint.
d. In all cases as the Reset Source value moves within its range established by the configured High and Low Reset Setpoints, the Supply Air Setpoint will be proportionally reset within its range established by the configured Low and High SAT Setpoints.
e. Dehumidification in All Modes shall be configured. If the unit is in Cooling Dehumidification or the Heating Dehumidification Mode, the SAT reset will occur as described above.
f. In the Vent Mode or the Vent Dehumidification Mode, the SAT Setpoint shall be calculated to be halfway between the HVAC Mode Enable Setpoints.

17. Coil Temperature Reset During Dehumidification
a. The Indoor Humidity shall be used to reset the (Saturation) Temperature Setpoint during Dehumidification.
b. A user adjustable indoor humidity range of 30%-55 % (adj) shall be created to proportionally reset the (Saturation) Temperature Setpoint within a user adjustable range.

1.5 QUARANTINE SYSTEM (ERV-2, AHU-2 and ASHP-2)

A. General
1. The quarantine system shall consist of an Energy Recovery Ventilator (ERV), Air Handing Unit (AHU) and an Air Source Heat Pump Unit (ASHP)
2. The ERV shall provide 100% tempered outside air to the air handling unit. The ERV shall be provided with complete controls from the unit manufacturer. All BACnet data available from the factory controller shall be interfaced with the BAS. ERV operation is based on specified manufacturer's standard sequence of operation and is included for reference. Other acceptable manufacturers shall follow their own sequence of operation.
3. The AHU-2 shall have factory provided controller and shall be interfaced with the BAS.
4. The system shall operate providing system safeties are satisfied.

B. ERV-2 Operation
1. ERV-2 shall run whenever AHU-2 runs.
2. ERV-2 shall run based on factory programmed sequence of operation.
3. ERV Unit Start Command
4. An input signal is required to enable the unit operation. The unit will be commanded on by:
1) Digital input
2) BAS command
b. All types of input that are enabled must be true before the unit will start.
1) The exhaust fan starts after a 3 second delay (adjustable). The exhaust fan will not start until the damper actuator end switch closes.
2) The supply fan starts after a 6 second delay (adjustable). The supply fan will not start until the damper actuator end switch closes.
3) The supply fan, exhaust fan, [economizer], [heating] are controlled based on the chosen unit operating modes and air conditions.
5. ERV Unit Stop Command
a. The unit can then be commanded off by:
1) Digital Input
2) BAS command
b. Supply fan and exhaust fan are de-energized.

c. All dampers are unpowered and spring return to their default position after a 10 second delay (adjustable).

6. Supply Fan Operation
   a. The supply fan shall operate at a constant speed.
   b. The unit will attempt to start the supply fan when the supply fan delay timer expires. When the supply fan starts the supply fan adjustable current switch should close and remain closed until the fan is turned off.
7. Supply Fan Status
   a. Once the supply fan current switch closes [heating] operation is allowed. After a delay of 90 seconds (adjustable) from supply fan start signal, if the supply fan current switch is still open the supply fan alarm should be set to true and [heating] operation shall be prohibited. The supply fan status shall be set to true only when the supply fan output is on and supply fan current switch is closed. The supply fan status shall be false in all other circumstances.
8. Supply Air Flow Control
   a. The controller will adjust the supply fan ECM command to maintain the supply air flow rate at a set point. The supply air flow rate set point is entered and adjusted from the unit controller display [or provided by the BMS]. The minimum and maximum values for supply air flow rate set point are unit dependent. An adjustable PI (proportional & integral) loop will compare the measured supply air flow to the air flow rate set point and adjust the fan speed. If the measured supply air flow rate varies from the desired air flow rate by more than 10% (adjustable) for more than 60 seconds (adjustable) a supply air flow rate alarm will be set to true. This supply fan operation mode can be used to provide a constant supply air flow rate as the unit filters become loaded.
9. Exhaust Fan Operation
   a. The exhaust fan will operate at a constant speed.
   b. The unit will attempt to start the exhaust fan when the exhaust fan delay timer expires. When the exhaust fan starts the exhaust fan adjustable current switch should close and remain closed until the fan is turned off.
10. Exhaust Fan Status
   a. After a delay of 90 seconds (adjustable) from exhaust fan start signal, if exhaust fan current switch is still open the exhaust fan alarm should be set to true. The exhaust fan status shall be set to true only when the exhaust fan output is on and exhaust fan current switch is closed. The exhaust fan status shall be false in all other circumstances.
11. Exhaust Air Flow Control
   a. The controller will adjust the exhaust fan ECM command to maintain the exhaust air flow rate at a set point. The exhaust air flow rate set point is entered and adjusted from the unit controller display [or provided by the BMS]. The minimum and maximum values for the exhaust air flow rate set point are unit dependent. An adjustable PI (proportional & integral) loop will compare the measured exhaust air flow to the air flow rate set point and adjust the fan speed. If the measured exhaust air flow rate varies from the desired air flow rate by more than 10% (adjustable) for more than 60 seconds (adjustable) an exhaust air flow rate alarm will be set to true. This exhaust fan operation mode can be used to provide a constant exhaust air flow rate as the unit filters become loaded.
12. Economizer (Bypass) Operation
   a. During normal operation the bypass damper shall remain closed and the face damper open to allow full energy recovery. During economizer operation the bypass damper will be open and the face damper will close to bypass the core. The economizer state can be controlled by enthalpy.
      1) The economizer will be locked out when:
      2) The outside air enthalpy is greater than return air enthalpy.

3) The outside air temperature is less than the economizer field adjustable low lockout.

C. AHU-2 and ASHP-2 Operation

1. The AHU-2 and ASHP-2 shall be indexed for Occupied and Unoccupied modes by the BAS
2. Mode Enable Sensor Options
   a. The temperature of the space temperature sensor will determine whether the unit is in heating, cooling or vent mode during occupied operation.
3. Occupied Mode Initiation
   a. BACnet command
   b. Pushbutton Override button on a Space Sensor (Override length is user adjustable).

4. Unoccupied Operation
   a. If a space temperature sensor and/or an indoor humidity sensor are installed, the unit can use the Night Setback Offsets (applied to the Mode Enable Setpoints) for heating and cooling calls and the normal Dehumidification Setpoint (no offset) for dehumidification calls.
   b. If there is no call for Heating or Cooling, or if Night Setback operation has not been configured, the unit will be Off.
5. HVAC Modes of Operation
   a. Cooling Mode
   b. Heating Mode
   c. Vent Mode
   d. Dehumidification Mode
   e. Off Mode
6. Cooling Mode with Variable Capacity Compressor
   a. Cooling is enabled when the temperature at the Mode Enable Sensor rises one deadband above the Cooling Setpoint. Cooling is disabled when the Mode Enable temperature falls one deadband below the Cooling Setpoint. The setpoint and deadband are user adjustable.
   b. In the cooling mode, as the Supply Air Temperature (SAT) rises above the Active Supply Air Cooling Setpoint (see Supply Air Temperature Setpoint Reset section for explanation), compressors will modulate and stage based on the unit configuration in order to control to the Active Supply Air Cooling Setpoint.
   c. Each stage must meet its Minimum Off Time (adj.) before it is allowed to energize and successive stages can energize if the SAT rises above the Active Supply Air Cooling Setpoint for the Cooling Stage Up Delay period (adj).
   d. For compressors to stage down Minimum Run Times (adj.) must be satisfied, and the SAT needs to be below the Active Supply Air Cooling Setpoint minus the Cooling Stage Control for a period of time equal to the Stage Down Delay.
   e. Mechanical cooling is disabled if the Outdoor Air Temperature (OAT) falls 1° below the Cooling Lockout Setpoint and will remain disabled until the OAT rises 1° above the Cooling Lockout Setpoint. If the OAT disables mechanical cooling while it is currently operating, mechanical cooling will stage off as minimum run times and stage down delays are satisfied.
7. Heating Mode
   a. Heating is enabled when the temperature at the Mode Enable Sensor falls one deadband below the Heating Setpoint. Heating is disabled when the Mode Enable temperature rises one deadband above the Heating Setpoint.
   b. In the Heating Mode, as the Supply Air Temperature falls below the Active Supply Air Heating Setpoint (see Supply Air Temperature Setpoint Reset section for explanation), the heating will begin to stage on or to modulate. Each stage must

meet its Minimum Off Time (adj.) before it is allowed to energize and successive stages are subject to a Heating Stage Up Delay (adj).

c. Heating stages will continue to run until the supply air temperature rises above the Active Supply Air Temperature Setpoint plus the Heating Stage Control Window at which point the heating will begin to stage off. Each stage must meet its Minimum Run Time (adj.) before it is allowed to stage off, and successive stages are subject to a Heating Stage Down Delay (adj.).

d. Mechanical heating is disabled if the Outdoor Air Temperature (OAT) rises 1° above the Heating Lockout Setpoint and will remain disabled until the OAT falls 1° below the Heating Lockout Setpoint. If the OAT disables mechanical heating while it is currently operating, mechanical heating will stage off as minimum run times and stage down delays are satisfied.

8. Primary and Secondary Heating
   a. The Primary Heat shall be the Heat pump
   b. Secondary Heat would be a staged SCR Electric.
   c. If the Primary Heat modulates to 100%, Secondary Heat will then be allowed to stage on, while the Primary Heat is allowed to modulate between the stages as they stage up and down as needed to maintain the Heating Supply Air Setpoint.
   d. When outside air temperature drops below 10 deg F (adj), the primary heat will be off and the secondary heat shall be allowed to stage on.
9. Dehumidification Mode
   a. Dehumidification can be initiated anytime in the Occupied or Unoccupied Mode during Cooling, Heating, Vent, or Off Mode. This can create a Cooling Dehumidification Mode, a Heating Dehumidification Mode.
   b. Dehumidification is enabled when the Indoor Humidity rises above the Indoor Humidity Enable/Hi Reset Setpoint and is disabled when the Indoor Humidity falls below the Disable/Lo Reset Setpoint and requires the use of the E-BUS Combination Space (or Return Air) Temperature/Humidity Sensor.
   c. Dehumidification shall be selected as a priority mode and is then active anytime the humidity is above the Setpoint.
   d. Once in dehumidification, the unit will modulate the compressor in order maintain the Evaporator Coil Suction (Saturation) Temperature at the Coil Suction (Saturation) Temperature Setpoint.
   e. A coil suction pressure sensor is required and is typically factory installed.
   f. Modulating dehumidification Reheat is always controlled to the appropriate Active Supply Air Temperature Setpoint which will be dependent on whether you are in Cooling Dehumidification, Heating Dehumidification, or Vent Dehumidification. During Vent Mode Dehumidification the Supply Air Temperature Setpoint is calculated to be halfway between the HVAC Mode Setpoints.
10. Ventilation Mode
   a. This mode is only available in the Occupied Mode of operation on units configured for continuous supply fan operation and is generated anytime there is no demand for heating or cooling.
11. Air to Air Heat Pump Operation
   a. Cooling Mode will operate in the same manner as described in the Cooling section.
   b. A reversing valve relay output can be configured to activate with the first compressor stage in the Heating Mode or the Cooling Mode of operation.
   c. In the Heating Mode, Compressor Heat, Auxiliary Heat, and Emergency Heat can be used to achieve the Active Supply Air Temperature (SAT) Heating Setpoint. Auxiliary heat can be used in conjunction with compressor heat. Emergency heat can only be used if the compressors are locked out.
   d. Auxiliary Heat can be either a modulating or staged form of heat, or it can be a modulating form of heat followed by staged heat. Emergency heat can only be staged.
   e. Auxiliary Heat will only be enabled (after a stage up delay) when compressor heat has fully staged up and/or modulated to 100% and it still cannot maintain the

Heating Supply Air Setpoint. Any modulating compressor heat will be locked at 100% until the SAT rises above the SAT Heating Setpoint plus the Heating Stage Window. At that point, the Auxiliary Heat will stage off (after a stage down delay) and modulating compressor(s) heat will again be allowed to modulate.

f. When the Outdoor Air Temperature (OAT) is below the Heating Lockout but above the OAT Compressor Heating Lockout, Compressor Heat will be used and can be supplemented by Auxiliary Heat.

g. When the OAT is below the OAT Compressor Heating Lockout, Compressor Heat is locked out. Auxiliary Heat will then be the primary heat and can be supplemented with stage(s) of Emergency Heat (if available). Emergency heat is only available when the OAT is below the OAT Compressor Lockout.

12. Heat Pump Standard Defrost Operation
    a. If the compressor(s) are operating in the Heating Mode and the Defrost Coil Temperature Switch closes, the unit will enter the Defrost Mode, provided the user-adjustable Defrost Interval Timer has elapsed since the last Defrost Cycle.
    b. In the Defrost Cycle, the reversing valve signal is switched to the opposite operation, and the compressors are brought to maximum capacity. Auxiliary Heat will be used to attempt to maintain the Heating SAT Setpoint.
    c. The unit will leave the Defrost Mode after 10 minutes have elapsed or the Defrost Coil Temperature Switch opens - whichever happens first.
    d. If the unit leaves the compressor heating mode, the Defrost Interval timer will restart once the unit re-enters the compressor heating mode.
13. Space Sensor Operation
    a. Sensor with Override and Setpoint Slide Adjust.
    b. Sensors with Setpoint Slide Adjust can be programmed to allow space setpoint adjustment of up to +/- 10° F.
    c. The Slide Adjust can adjust the setpoint of whichever temperature sensor is configured as the controlling sensor, even if it is not the installed Space Sensor. If Space Temperature is the SAT/Reset Source, then the Slide Adjust will adjust the HVAC Mode Enable setpoints and the SAT/Reset Source setpoints simultaneously.
    d. During Unoccupied hours the Override Button can be used to force the unit back into the Occupied Mode (by pressing the button for less than 3 seconds) for a user-defined override duration of up to 8.0 hours. Pressing the button between 3 and 10 seconds cancels the override.
14. Supply Fan Operation
    a. Occupied Mode – Supply fan shall be configured to run continuously.
    b. Unoccupied Mode – Supply fan shall cycle on a call for heating, cooling or dehumidification.
    c. Anytime the Supply Fan is requested to start, a 1 minute minimum off timer must be satisfied. If the timer is satisfied the Supply Fan relay is activated while all other outputs are held off for a period of 1-2 minutes to purge stagnate air from the ductwork before heating or cooling occurs.
    d. In fan cycle mode or when going unoccupied the supply fan is held on for 2 minutes after the last stage of heating or cooling stages off.
15. Head Pressure Control
    a. The factory provided controller shall monitor head pressure transducers and control multiple fans or valves to maintain the head pressure setpoint.
    b. Different head pressure setpoints shall be used for Cooling Mode and Dehumidification Reheat Mode
    c. Modulating condenser signal is always 100% during heat pump Heating Mode.
16. Supply Air Temperature Setpoint Reset
    a. Reset the Supply Air Temperature (SAT) Setpoint based on space temperature.
    b. A High and a Low Reset Source Setpoint shall be configured that will correspond to configured Low and High SAT Setpoints. This must be done separately for the Cooling Mode setpoints and for the Heating Mode setpoints.

c. When the Reset Source is at its highest configured setpoint the SAT Setpoint will be reset to its lowest configured setpoint. When the Reset Source is at its lowest configured setpoint the SAT Setpoint will be reset to its highest configured setpoint.
d. In all cases as the Reset Source value moves within its range established by the configured High and Low Reset Setpoints, the Supply Air Setpoint will be proportionally reset within its range established by the configured Low and High SAT Setpoints.
e. Dehumidification in All Modes shall be configured. If the unit is in Cooling Dehumidification or the Heating Dehumidification Mode, the SAT reset will occur as described above.
f. In the Vent Mode or the Vent Dehumidification Mode, the SAT Setpoint shall be calculated to be halfway between the HVAC Mode Enable Setpoints.

17. Coil Temperature Reset During Dehumidification
a. The Indoor Humidity shall be used to reset the (Saturation) Temperature Setpoint during Dehumidification.
b. A user adjustable indoor humidity range of 30%-55 % (adj) shall be created to proportionally reset the (Saturation) Temperature Setpoint within a user adjustable range.

1.6 CATTERY SYSTEM (ERV-3, AHU-3 and ASHP-3)

A. General
1. The quarantine system shall consist of an Energy Recovery Ventilator (ERV), Air Handing Unit (AHU) and an Air Source Heat Pump Unit (ASHP)
2. The ERV shall provide 100% tempered outside air to the air handling unit. The ERV shall be provided with complete controls from the unit manufacturer. All BACnet data available from the factory controller shall be interfaced with the BAS. ERV operation is based on specified manufacturer's standard sequence of operation and is included for reference. Other acceptable manufacturers shall follow their own sequence of operation.
3. The AHU-3 shall have factory provided controller and shall be interfaced with the BAS.
4. The system shall operate providing system safeties are satisfied.

B. ERV-3 Operation
1. ERV-3 shall run whenever AHU-3 runs.
2. ERV-3 shall run based on factory programmed sequence of operation.
3. ERV Unit Start Command
4. An input signal is required to enable the unit operation. The unit will be commanded on by:
1) Digital input
2) BAS command
b. All types of input that are enabled must be true before the unit will start.
1) The exhaust fan starts after a 3 second delay (adjustable). The exhaust fan will not start until the damper actuator end switch closes.
2) The supply fan starts after a 6 second delay (adjustable). The supply fan will not start until the damper actuator end switch closes.
3) The supply fan, exhaust fan, [economizer], [heating] are controlled based on the chosen unit operating modes and air conditions.
5. ERV Unit Stop Command
a. The unit can then be commanded off by:
1) Digital Input
2) BAS command
b. Supply fan and exhaust fan are de-energized.

c. All dampers are unpowered and spring return to their default position after a 10 second delay (adjustable).

6. Supply Fan Operation
   a. The supply fan shall operate at a constant speed.
   b. The unit will attempt to start the supply fan when the supply fan delay timer expires. When the supply fan starts the supply fan adjustable current switch should close and remain closed until the fan is turned off.
7. Supply Fan Status
   a. Once the supply fan current switch closes [heating] operation is allowed. After a delay of 90 seconds (adjustable) from supply fan start signal, if the supply fan current switch is still open the supply fan alarm should be set to true and [heating] operation shall be prohibited. The supply fan status shall be set to true only when the supply fan output is on and supply fan current switch is closed. The supply fan status shall be false in all other circumstances.
8. Supply Air Flow Control
   a. The controller will adjust the supply fan ECM command to maintain the supply air flow rate at a set point. The supply air flow rate set point is entered and adjusted from the unit controller display [or provided by the BMS]. The minimum and maximum values for supply air flow rate set point are unit dependent. An adjustable PI (proportional & integral) loop will compare the measured supply air flow to the air flow rate set point and adjust the fan speed. If the measured supply air flow rate varies from the desired air flow rate by more than 10% (adjustable) for more than 60 seconds (adjustable) a supply air flow rate alarm will be set to true. This supply fan operation mode can be used to provide a constant supply air flow rate as the unit filters become loaded.
9. Exhaust Fan Operation
   a. The exhaust fan will operate at a constant speed.
   b. The unit will attempt to start the exhaust fan when the exhaust fan delay timer expires. When the exhaust fan starts the exhaust fan adjustable current switch should close and remain closed until the fan is turned off.
10. Exhaust Fan Status
    a. After a delay of 90 seconds (adjustable) from exhaust fan start signal, if exhaust fan current switch is still open the exhaust fan alarm should be set to true. The exhaust fan status shall be set to true only when the exhaust fan output is on and exhaust fan current switch is closed. The exhaust fan status shall be false in all other circumstances.
11. Exhaust Air Flow Control
    a. The controller will adjust the exhaust fan ECM command to maintain the exhaust air flow rate at a set point. The exhaust air flow rate set point is entered and adjusted from the unit controller display [or provided by the BMS]. The minimum and maximum values for the exhaust air flow rate set point are unit dependent. An adjustable PI (proportional & integral) loop will compare the measured exhaust air flow to the air flow rate set point and adjust the fan speed. If the measured exhaust air flow rate varies from the desired air flow rate by more than 10% (adjustable) for more than 60 seconds (adjustable) an exhaust air flow rate alarm will be set to true. This exhaust fan operation mode can be used to provide a constant exhaust air flow rate as the unit filters become loaded.
12. Economizer (Bypass) Operation
    a. During normal operation the bypass damper shall remain closed and the face damper open to allow full energy recovery. During economizer operation the bypass damper will be open and the face damper will close to bypass the core. The economizer state can be controlled by enthalpy.
       1) The economizer will be locked out when:
       2) The outside air enthalpy is greater than return air enthalpy.

3) The outside air temperature is less than the economizer field adjustable low lockout.

C. AHU-3 and ASHP-3 Operation

1. The AHU-3 and ASHP-3 shall be indexed for Occupied and Unoccupied modes by the BAS
2. Mode Enable Sensor Options
   a. The temperature of the space temperature sensor will determine whether the unit is in heating, cooling or vent mode during occupied operation.
3. Occupied Mode Initiation
   a. BACnet command
   b. Pushbutton Override button on a Space Sensor (Override length is user adjustable).

4. Unoccupied Operation
   a. If a space temperature sensor and/or an indoor humidity sensor are installed, the unit can use the Night Setback Offsets (applied to the Mode Enable Setpoints) for heating and cooling calls and the normal Dehumidification Setpoint (no offset) for dehumidification calls.
   b. If there is no call for Heating or Cooling, or if Night Setback operation has not been configured, the unit will be Off.
5. HVAC Modes of Operation
   a. Cooling Mode
   b. Heating Mode
   c. Vent Mode
   d. Dehumidification Mode
   e. Off Mode
6. Cooling Mode with Variable Capacity Compressor
   a. Cooling is enabled when the temperature at the Mode Enable Sensor rises one deadband above the Cooling Setpoint. Cooling is disabled when the Mode Enable temperature falls one deadband below the Cooling Setpoint. The setpoint and deadband are user adjustable.
   b. In the cooling mode, as the Supply Air Temperature (SAT) rises above the Active Supply Air Cooling Setpoint (see Supply Air Temperature Setpoint Reset section for explanation), compressors will modulate and stage based on the unit configuration in order to control to the Active Supply Air Cooling Setpoint.
   c. Each stage must meet its Minimum Off Time (adj.) before it is allowed to energize and successive stages can energize if the SAT rises above the Active Supply Air Cooling Setpoint for the Cooling Stage Up Delay period (adj).
   d. For compressors to stage down Minimum Run Times (adj.) must be satisfied, and the SAT needs to be below the Active Supply Air Cooling Setpoint minus the Cooling Stage Control for a period of time equal to the Stage Down Delay.
   e. Mechanical cooling is disabled if the Outdoor Air Temperature (OAT) falls 1° below the Cooling Lockout Setpoint and will remain disabled until the OAT rises 1° above the Cooling Lockout Setpoint. If the OAT disables mechanical cooling while it is currently operating, mechanical cooling will stage off as minimum run times and stage down delays are satisfied.
7. Heating Mode
   a. Heating is enabled when the temperature at the Mode Enable Sensor falls one deadband below the Heating Setpoint. Heating is disabled when the Mode Enable temperature rises one deadband above the Heating Setpoint.
   b. In the Heating Mode, as the Supply Air Temperature falls below the Active Supply Air Heating Setpoint (see Supply Air Temperature Setpoint Reset section for explanation), the heating will begin to stage on or to modulate. Each stage must

meet its Minimum Off Time (adj.) before it is allowed to energize and successive stages are subject to a Heating Stage Up Delay (adj).

c. Heating stages will continue to run until the supply air temperature rises above the Active Supply Air Temperature Setpoint plus the Heating Stage Control Window at which point the heating will begin to stage off. Each stage must meet its Minimum Run Time (adj.) before it is allowed to stage off, and successive stages are subject to a Heating Stage Down Delay (adj.).

d. Mechanical heating is disabled if the Outdoor Air Temperature (OAT) rises 1° above the Heating Lockout Setpoint and will remain disabled until the OAT falls 1° below the Heating Lockout Setpoint. If the OAT disables mechanical heating while it is currently operating, mechanical heating will stage off as minimum run times and stage down delays are satisfied.

8. Primary and Secondary Heating
   a. The Primary Heat shall be the Heat pump
   b. Secondary Heat would be a staged SCR Electric.
   c. If the Primary Heat modulates to 100%, Secondary Heat will then be allowed to stage on, while the Primary Heat is allowed to modulate between the stages as they stage up and down as needed to maintain the Heating Supply Air Setpoint.
   d. When outside air temperature drops below 10 deg F (adj), the primary heat will be off and the secondary heat shall be allowed to stage on.
9. Dehumidification Mode
   a. Dehumidification can be initiated anytime in the Occupied or Unoccupied Mode during Cooling, Heating, Vent, or Off Mode. This can create a Cooling Dehumidification Mode, a Heating Dehumidification Mode.
   b. Dehumidification is enabled when the Indoor Humidity rises above the Indoor Humidity Enable/Hi Reset Setpoint and is disabled when the Indoor Humidity falls below the Disable/Lo Reset Setpoint and requires the use of the E-BUS Combination Space (or Return Air) Temperature/Humidity Sensor.
   c. Dehumidification shall be selected as a priority mode and is then active anytime the humidity is above the Setpoint.
   d. Once in dehumidification, the unit will modulate the compressor in order maintain the Evaporator Coil Suction (Saturation) Temperature at the Coil Suction (Saturation) Temperature Setpoint.
   e. A coil suction pressure sensor is required and is typically factory installed.
   f. Modulating dehumidification Reheat is always controlled to the appropriate Active Supply Air Temperature Setpoint which will be dependent on whether you are in Cooling Dehumidification, Heating Dehumidification, or Vent Dehumidification. During Vent Mode Dehumidification the Supply Air Temperature Setpoint is calculated to be halfway between the HVAC Mode Setpoints.
10. Ventilation Mode
   a. This mode is only available in the Occupied Mode of operation on units configured for continuous supply fan operation and is generated anytime there is no demand for heating or cooling.
11. Air to Air Heat Pump Operation
   a. Cooling Mode will operate in the same manner as described in the Cooling section.
   b. A reversing valve relay output can be configured to activate with the first compressor stage in the Heating Mode or the Cooling Mode of operation.
   c. In the Heating Mode, Compressor Heat, Auxiliary Heat, and Emergency Heat can be used to achieve the Active Supply Air Temperature (SAT) Heating Setpoint. Auxiliary heat can be used in conjunction with compressor heat. Emergency heat can only be used if the compressors are locked out.
   d. Auxiliary Heat can be either a modulating or staged form of heat, or it can be a modulating form of heat followed by staged heat. Emergency heat can only be staged.
   e. Auxiliary Heat will only be enabled (after a stage up delay) when compressor heat has fully staged up and/or modulated to 100% and it still cannot maintain the

Heating Supply Air Setpoint. Any modulating compressor heat will be locked at 100% until the SAT rises above the SAT Heating Setpoint plus the Heating Stage Window. At that point, the Auxiliary Heat will stage off (after a stage down delay) and modulating compressor(s) heat will again be allowed to modulate.

f. When the Outdoor Air Temperature (OAT) is below the Heating Lockout but above the OAT Compressor Heating Lockout, Compressor Heat will be used and can be supplemented by Auxiliary Heat.

g. When the OAT is below the OAT Compressor Heating Lockout, Compressor Heat is locked out. Auxiliary Heat will then be the primary heat and can be supplemented with stage(s) of Emergency Heat (if available). Emergency heat is only available when the OAT is below the OAT Compressor Lockout.

12. Heat Pump Standard Defrost Operation
    a. If the compressor(s) are operating in the Heating Mode and the Defrost Coil Temperature Switch closes, the unit will enter the Defrost Mode, provided the user-adjustable Defrost Interval Timer has elapsed since the last Defrost Cycle.
    b. In the Defrost Cycle, the reversing valve signal is switched to the opposite operation, and the compressors are brought to maximum capacity. Auxiliary Heat will be used to attempt to maintain the Heating SAT Setpoint.
    c. The unit will leave the Defrost Mode after 10 minutes have elapsed or the Defrost Coil Temperature Switch opens - whichever happens first.
    d. If the unit leaves the compressor heating mode, the Defrost Interval timer will restart once the unit re-enters the compressor heating mode.
13. Space Sensor Operation
    a. Sensor with Override and Setpoint Slide Adjust.
    b. Sensors with Setpoint Slide Adjust can be programmed to allow space setpoint adjustment of up to +/- 10° F.
    c. The Slide Adjust can adjust the setpoint of whichever temperature sensor is configured as the controlling sensor, even if it is not the installed Space Sensor. If Space Temperature is the SAT/Reset Source, then the Slide Adjust will adjust the HVAC Mode Enable setpoints and the SAT/Reset Source setpoints simultaneously.
    d. During Unoccupied hours the Override Button can be used to force the unit back into the Occupied Mode (by pressing the button for less than 3 seconds) for a user-defined override duration of up to 8.0 hours. Pressing the button between 3 and 10 seconds cancels the override.
14. Supply Fan Operation
    a. Occupied Mode – Supply fan shall be configured to run continuously.
    b. Unoccupied Mode – Supply fan shall cycle on a call for heating, cooling or dehumidification.
    c. Anytime the Supply Fan is requested to start, a 1 minute minimum off timer must be satisfied. If the timer is satisfied the Supply Fan relay is activated while all other outputs are held off for a period of 1-2 minutes to purge stagnate air from the ductwork before heating or cooling occurs.
    d. In fan cycle mode or when going unoccupied the supply fan is held on for 2 minutes after the last stage of heating or cooling stages off.
15. Head Pressure Control
    a. The factory provided controller shall monitor head pressure transducers and control multiple fans or valves to maintain the head pressure setpoint.
    b. Different head pressure setpoints shall be used for Cooling Mode and Dehumidification Reheat Mode
    c. Modulating condenser signal is always 100% during heat pump Heating Mode.
16. Supply Air Temperature Setpoint Reset
    a. Reset the Supply Air Temperature (SAT) Setpoint based on space temperature.
    b. A High and a Low Reset Source Setpoint shall be configured that will correspond to configured Low and High SAT Setpoints. This must be done separately for the Cooling Mode setpoints and for the Heating Mode setpoints.

c. When the Reset Source is at its highest configured setpoint the SAT Setpoint will be reset to its lowest configured setpoint. When the Reset Source is at its lowest configured setpoint the SAT Setpoint will be reset to its highest configured setpoint.
d. In all cases as the Reset Source value moves within its range established by the configured High and Low Reset Setpoints, the Supply Air Setpoint will be proportionally reset within its range established by the configured Low and High SAT Setpoints.
e. Dehumidification in All Modes shall be configured. If the unit is in Cooling Dehumidification or the Heating Dehumidification Mode, the SAT reset will occur as described above.
f. In the Vent Mode or the Vent Dehumidification Mode, the SAT Setpoint shall be calculated to be halfway between the HVAC Mode Enable Setpoints.

17. Coil Temperature Reset During Dehumidification
a. The Indoor Humidity shall be used to reset the (Saturation) Temperature Setpoint during Dehumidification.
b. A user adjustable indoor humidity range of 30%-55 % (adj) shall be created to proportionally reset the (Saturation) Temperature Setpoint within a user adjustable range.

1.7 VRF-1 and ERV-4

A. General:
1. The system shall consist of an energy recovery unit and VRF system.
2. The ERV shall provide 100% tempered outside air to the VRF indoor fan coil units. The ERV shall be provided with complete controls from the unit manufacturer. All BACnet data available from the factory controller shall be interfaced with the BAS. ERV operation is based on specified manufacturer's standard sequence of operation and is included for reference. Other acceptable manufacturers shall follow their own sequence of operation.
3. ERV-4 shall run during occupied hours and shall be off during unoccupied hours. Coordinate occupied and unoccupied hours with the Owner.
4. The system shall operate providing system safeties are satisfied.

B. ERV-4 Operation
1. ERV-4 shall run based on factory programmed sequence of operation.
2. ERV Unit Start Command
3. An input signal is required to enable the unit operation. The unit will be commanded on by:
1) Digital input
2) BAS command
3) Internal timeclock
b. All types of input that are enabled must be true before the unit will start.
1) The supply fan starts after a 6 second delay (adjustable). The supply fan will not start until the damper actuator end switch closes.
2) The supply fan is controlled based on the chosen unit operating modes and air conditions.
4. ERV Unit Stop Command
a. The unit can then be commanded off by:
1) Digital Input
2) BAS command
3) Internal timeclock
b. Supply fan is de-energized.

c. All dampers are unpowered and spring return to their default position after a 10 second delay (adjustable).

5. Supply Fan Operation
   a. The supply fan shall operate at a constant speed.
   b. The unit will attempt to start the supply fan when the supply fan delay timer expires. When the supply fan starts the supply fan adjustable current switch should close and remain closed until the fan is turned off.
6. Supply Fan Status
   a. Once the supply fan current switch closes, operation is allowed. After a delay of 90 seconds (adjustable) from supply fan start signal, if the supply fan current switch is still open the supply fan alarm should be set to true and [heating] operation shall be prohibited. The supply fan status shall be set to true only when the supply fan output is on and supply fan current switch is closed. The supply fan status shall be false in all other circumstances.
7. Supply Air Flow Control
   a. The controller will adjust the supply fan ECM command to maintain the supply air flow rate at a set point. The supply air flow rate set point is entered and adjusted from the unit controller display. The minimum and maximum values for supply air flow rate set point are unit dependent. An adjustable PI (proportional & integral) loop will compare the measured supply air flow to the air flow rate set point and adjust the fan speed. If the measured supply air flow rate varies from the desired air flow rate by more than 10% (adjustable) for more than 60 seconds (adjustable) a supply air flow rate alarm will be set to true. This supply fan operation mode can be used to provide a constant supply air flow rate as the unit filters become loaded.

C. VRF-1 Operation
1. The VRF system shall follow the manufacturer's sequence of operation. All controllers shall be provided by the VRF system manufacturer.
2. The ATC Contractor shall be responsible for installation and communication wiring of all VRF control components to provide a complete and operational system including but not limited to wall mounted controller, return air thermistors and outdoor unit. The VRF manufacturer Shall furnish wall-mounted controller remote and return air thermistors. VRF manufacturer shall coordinate and provide required documentation and support services.
3. Initial Setpoints: Initial space temperature setpoints shall be as follows:

Occupied	Unoccupied
Heating: 70°F	Heating: 60°F
Cooling: 75°F	Cooling: 82°F

4. Remote controllers control the operation of the indoor units. Desired occupied and unoccupied heating and cooling set-points are programmed via wall controllers. Fan operation is determined by the position of the "ON-AUTO" switch.
5. Un-Occupied Mode:
   a. During unoccupied mode, the associated ERV-4 shall be off. The return air motorized damper for the ducted FCU-1-1 shall be fully open.
   b. Heating Mode Control: VRF shall be indexed to Heating Mode when space temperature decreases below unoccupied heating setpoint.
   c. Cooling Mode Control: VRF shall be indexed to Cooling Mode when space temperature increases above unoccupied cooling setpoint.
6. Morning Warm-Up Mode Control: When space temperature decreases below morning warm-up setpoint, the VRF shall be indexed to Heating Mode.
7. Occupied Mode:
   a. During occupied mode, the return air motorized damper for the ducted FCU-1-1 shall be fully closed.

b. Occupied Standby Mode: When the space temperature setpoint is within the heating and cooling dead-band, the VRF shall be indexed into Fan Mode.
c. Occupied Heating Mode: When space temperature decreases below occupied heating setpoint, the VRF will be indexed to the Heating Mode.
d. Occupied Cooling Mode: VRF shall be indexed to Cooling Mode when space temperature increases above occupied cooling setpoint (adj.).

8. Condensate Overflow Shutdown:
   a. The VRF factory built-in condensate pump, check valve, and float switch shall disable the indoor VRF unit during an overflow detection and generate an error code alarm.
   b. A secondary drain pan moisture sensor shall disable the indoor unit when moisture is sensed at the drain pan.

1.8 TOILET EXHAUST FAN (EF-1)

A. The exhaust fans shall be interlocked with the occupancy sensor.

B. The exhaust fan shall run when toilet room is occupied.

1.9 GROOMING/LAUNDRY EXHAUST FAN (EF-2)

A. The exhaust fans shall be interlocked with the wall switch.

B. The exhaust fan shall run when wall switch is activated and will run at predetermined length of time.
   1. When the exhaust fan is activated, the transfer duct motorized damper shall open.
   2. When the exhaust fan is deactivated, the transfer duct motorized damper shall close.

1.10 MECHANICAL ROOM TEMPERATURE AND VENTILATION CONTROL (EF-3)

A. An exhaust fan and motorized exhaust air damper shall be provided for ventilation for Mechanical Room. The actuators shall be provided with built-in auxiliary switch.

B. When the Mechanical room is occupied, as sensed by the occupancy sensor, the exhaust air damper will open, once damper is proven open, the exhaust fan shall run.

C. When the Mechanical room wall mounted space sensor rises above 85 deg F, the exhaust air damper will open, once damper is proven open, the exhaust fan shall run. Once the space temperature drops below 75 deg F, the exhaust fan shall be deenergized and the exhaust damper shall close.

D. The electric wall heater (EWH-2) shall operate to maintain unit mounted thermostat setpoint of 60 deg F (adj).

1.11 ELECTRICAL ROOM TEMPERATURE AND VENTILATION CONTROL (EF-4)

A. An exhaust fan and motorized exhaust air damper shall be provided for ventilation for Electrical Room. The actuators shall be provided with built-in auxiliary switch.

B. When the Electrical room is occupied, as sensed by the occupancy sensor, the exhaust air damper will open, once damper is proven open, the exhaust fan shall run.

C. When the Electrical room wall mounted space sensor rises above 85 deg F, the exhaust air damper will open, once damper is proven open, the exhaust fan shall run. Once the space temperature drops below 75 deg F, the exhaust fan shall be deenergized and the exhaust damper shall close.

D. The electric wall heater (EWH-3) shall operate to maintain unit mounted thermostat setpoint of 60 deg F (adj).

1.12 DRYER BOOSTER FAN (EF-5)

A. Dryer booster fan shall run when the dryer is in use.

B. The dryer booster shall turn ON approximately 10 seconds after the dryer has started by sensing the pressure inside the exhaust duct though the fan manufacturer provided pressure sensing switch.

1. A blue LED will illuminate (solid) on the indicator panel when the booster fan is operating.
2. Once ON, the booster fan will run continuously for 5 minutes. After 5 minutes, the booster fan will temporarily turn off to verify the status of the dryer. If the dryer is still running and positive pressure is sensed within the exhaust duct, the booster fan will re-energize and run another 5-minute cycle.
3. The indicator panel will remain lit during this verification step.
4. If after a complete 5-minute run cycle the pressure sensing switch does not sense pressure from the dryer, the booster fan will engage in a final 5-minute cool down process before turning off.

C. If the fan fails to operate while the dryer is running, alarm shall be generated at the workstation.

1.13 ATTIC TEMPERATURE AND VENTILATION CONTROL (EF-6):

A. An outside air damper and in-line exhaust fan with motorized damper shall be provided for ventilation.

B. Mechanical Contractor shall provide line voltage wall mounted thermostat, outside air damper with two(2) position, spring return, line voltage actuator. The actuator shall be provided with built-in auxiliary switches.

C. On a rise in space temperature above 85 F (adj.) as sensed by a wall mounted thermostat, the outside air and exhaust air dampers shall open, once dampers are proven open, the exhaust fan shall run. Once the space temperature drops below 80 F (adj), the exhaust fan shall cycle off, the outside air and exhaust air dampers shall close.

D. When attic light switch is activated, the outside air and exhaust air dampers shall open, once dampers are proven open, the exhaust fan shall run. When light switch is turned off, the exhaust fan shall cycle off, the outside air and exhaust air dampers shall close.

E. Electric unit heater (EUH-1) shall be provided for heating. The hot water valve shall modulate to maintain space temperature setpoint of 50 deg F (adj).

1.14 ELECTRIC WALL HEATERS (EWH-1 and EWH-4)

A. The electric wall heater shall be provided with unit mounted thermostat.

B. The electric wall heater shall operate to maintain unit mounted thermostat setpoint of 65 deg F (adj).

END OF SECTION 230993

SECTION 232300 - REFRIGERANT PIPING

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. Refrigerant pipes and fittings.
2. Refrigerant piping valves and specialties.
3. Refrigerants.

B. Related Sections include the following:

1. Section 230719 "HVAC Piping Insulation".
2. Section 238126 “Split-System Air-Conditioners”.
3. Section 238129 “Variable-Refrigerant-Flow HVAC Systems”.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve, refrigerant piping, and piping specialty.

1. Include pressure drop, based on manufacturer's test data, for the following:

a. Thermostatic expansion valves.
b. Solenoid valves.
c. Hot-gas bypass valves.
d. Filter dryers.
e. Strainers.
f. Pressure-regulating valves.

B. HPBS Submittals:

1. Product Data for Section 16a-38k-3(k): For refrigerant to be free of CFC.

C. Shop Drawings:

1. Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes; flow capacities; valve arrangements and locations; slopes of horizontal runs; oil traps; double risers; wall and floor penetrations; and equipment connection details.
2. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
3. Show interface and spatial relationships between piping and equipment.
4. Shop Drawing Scale: ¼-inch equals 1 foot.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.7 PRODUCT STORAGE AND HANDLING

A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig.
2. Suction Lines for Heat-Pump Applications: 535 psig.
3. Hot-Gas and Liquid Lines: 535 psig.

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 280, Type ACR.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Brazing Filler Metals: AWS A5.8.

E. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum ¾-inch misalignment in minimum 7-inch- long assembly.
4. Working Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.3 VALVES AND SPECIALTIES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Danfoss Inc.
2. Heldon Products; Henry Technologies
3. Parker Hannifin Corp.
4. Paul Mueller Company

B. Diaphragm Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless-steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

C. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

D. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless-steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg F.

E. Service Valves:
1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

F. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (NRTL).

1. Body and Bonnet: Plated steel.

2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless-steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with ½-inch conduit adapter, and appropriate voltage ac coil.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.

G. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless-steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 deg F.

H. Thermostatic Expansion Valves: Comply with AHRI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless-steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature:40 deg F.
6. Superheat: Adjustable.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: 700 psig.

I. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.

1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless-steel.
3. Packing and Gaskets: Non-asbestos.
4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless-steel.
5. Seat: Polytetrafluoroethylene.
6. Equalizer: External.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with ½-inch conduit adapter and 24-V ac coil.
8. End Connections: Socket.
9. Throttling Range: Maximum 5 psig
10. Working Pressure Rating: 500 psig.
11. Maximum Operating Temperature: 240 deg F.

J. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

K. Moisture/Liquid Indicators:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in parts per million (ppm).
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 deg F.

L. Replaceable-Core Filter Dryers: Comply with AHRI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina or charcoal.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 240 deg F.

M. Permanent Filter Dryers: Comply with AHRI 730.

1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 240 deg F.

N. Receivers: Comply with AHRI 495.

1. Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

O. Liquid Accumulators: Comply with AHRI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

2.4 REFRIGERANTS

A. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

B. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants
4. INEOS Fluor Americas LLC

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

B. Hot-Gas and Liquid Lines: Copper, Type ACR annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.

E. Install a full-size, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two (2) bulb straps. Do not mount bulb in a trap or at bottom of the line.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:

1. Solenoid valves.
2. Thermostatic expansion valves.
3. Hot-gas bypass valves.
4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993 "Sequence of Operations for HVAC DDC" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

P. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

R. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 PIPE JOINT CONSTRUCTION

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

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.

F. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and to restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic restraints in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Comply with Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

D. Install hangers for copper tubing, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Support horizontal piping within 12 inches of each fitting.

F. Support vertical runs of copper tubing to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.

    a. Leak testing shall be in accordance with the associated equipment manufacturer’s requirements.
    b. If leak is detected, remake leaking joints using new materials and retest in accordance with the associated equipment manufacturer’s requirements.

B. Prepare test and inspection reports.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 233113 - METAL DUCTS

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. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.
7. Seismic-restraint devices.

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.
13. Preparation for selecting hangers and supports and seismic restraints.

C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

A. 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. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Perimeter moldings.

B. Welding certificates.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Lindab Inc.
    b. McGill AirFlow LLC
    c. SEMCO Incorporated
    d. Sheet Metal Connectors, Inc.
    e. Spiral Manufacturing Co., Inc.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support

intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A 1008, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A 480, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

E. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

F. Reinforcement Shapes and Plates: ASTM A 36, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

G. Tie Rods: Galvanized steel, ¼-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 DUCT LINER

A. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

B. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Aeroflex USA, Inc.; **Aerocel**, minimum R value of 6
2. Armacell LLC; **AP Armaflex Duct Liner**, minimum R value of 6
3. K-Flex USA; **K-Flex Duct Liner Gray**, minimum R value of 6

C. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

D. Liner Thickness: Thickness shall conform with minimum R values in accordance with current International Energy Conservation Code.

E. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

F. Adhesive shall have a VOC content of 80 g/L or less.

G. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1½-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel or stainless-steel; with beveled edge sized as required to hold insulation securely in place but not less than 1½ inches in diameter.

H. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least ninety percent (90%) adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

    a. Fan discharges.
    b. Intervals of lined duct preceding unlined duct.
    c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.

    a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of twenty-three percent (23%).

10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.5 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum sixty-five percent (65%).
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless-steel, or aluminum sheets.

C. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

E. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1-inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal

flanges of same metal thickness as the duct. Overlap openings on four (4) sides by at least 1½ inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

M. Elbows: Use long-radius elbows wherever they fit.

1. Fabricate 90-degree rectangular mitered elbows to include double wall turning vanes.
2. Fabricate 90-degree round elbows with a minimum of three (3) segments for 12 inches and smaller and a minimum of five (5) segments for 14 inches and larger.

N. Branch Connections: Use lateral or conical branch connections.

O. Install acoustic lagging material where indicated on plans.

3.2 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

C. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Outdoor, Supply-Air Ducts: Seal Class A.
2. Outdoor, Exhaust Ducts: Seal Class A.
3. Outdoor, Return-Air Ducts: Seal Class A.
4. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class A.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
6. Unconditioned Space, Exhaust Ducts: Seal Class A.
7. Unconditioned Space, Return-Air Ducts: Seal Class A.
8. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class A.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
10. Conditioned Space, Exhaust Ducts: Seal Class A.
11. Conditioned Space, Return-Air Ducts: Seal Class A.
12. Conditioned Space, Return-Air Ducts: Seal Class A.

3.3 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5 "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum interval of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.4 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.5 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one (1) coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests: To be performed per system. A system will comprise of a mechanical equipment (such as air handling unit, exhaust fan) and associated duct distribution system.

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual".
2. Testing shall utilize currently certified test equipment. Submit a test report for each test.
3. Test the following systems:

    a. Supply Ducts with a Pressure Class of 1-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than fifty percent (50%) of total installed duct area for each designated pressure class.
    b. Return Ducts with a Pressure Class of 1-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than fifty percent (50%) of total installed duct area for each designated pressure class.

c. Exhaust Ducts with a Pressure Class of 1-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than fifty percent (50%) of total installed duct area for each designated pressure class.
d. Outdoor Air Ducts with a Pressure Class of 1-Inch wg: Test representative duct sections, selected by Architect from sections installed, totaling no less than fifty percent (50%) of total installed duct area for each designated pressure class.

4. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Leak testing shall be witnessed by the Construction Manager or Commissioning Authority. Give seven (7) day's notice prior to testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 DUCT CLEANING

A. Clean new duct systems before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).

2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.8 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.9 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
1. Dryer Exhaust Ducts: Stainless sheet.

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units:

a. Pressure Class: Positive 1-inch wg.

2. Ducts Connected to Air Handling Units and Energy Recovery Ventilators:

a. Pressure Class: Positive 3-inch wg.

C. Return Ducts:

1. Ducts Connected to Fan Coil Units:

a. Pressure Class: Negative 1-inch wg.

2. Ducts Connected to Rooftop Units and Dedicated Outdoor Air Units:

a. Pressure Class: Negative 3-inch wg.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

a. Pressure Class: Negative 2-inch wg.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 3-inch wg.

F. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.
2. Aluminum Ducts: Aluminum.

G. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 1000 fpm or Lower:

1) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
2) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
3) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two (2) vanes.

b. Velocity 1000 fpm to 1500 fpm:

1) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
2) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
3) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two (2) vanes.

c. Velocity 1500 fpm or Higher:

1) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
2) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
3) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two (2) vanes.

2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."

    a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

        1) Velocity 1000 fpm or Lower: 1.0 radius-to-diameter ratio and three (3) segments for 90-degree elbow.
        2) Velocity 1000 to 1500 fpm: 1.5 radius-to-diameter ratio and four (4) segments for 90-degree elbow.
        3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five (5) segments for 90-degree elbow.
        4) Radius-to Diameter Ratio: 1.5.

    b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
    c. Round Elbows, 14 Inches and Larger in Diameter: Welded.

H. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connections."

    a. Rectangular Main to Rectangular Branch: 45-degree entry.
    b. Rectangular Main to Round Branch: 45-degree entry and transition.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.

    a. Velocity 1000 fpm or Lower: 90-degree tap, conical.
    b. Velocity 1000 to 1500 fpm: Conical tap.
    c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

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. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Control dampers.
4. Flange connectors.
5. Turning vanes.
6. Duct-mounted access doors.
7. Flexible connectors.
8. Duct accessory hardware.

B. Related Requirements:

1. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible ducts.
2. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
3. Section 283111 "Digital, Addressable Fire-Alarm System" for duct-mounted fire and smoke detectors.

1.3 ACTION SUBMITTALS

A. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Special fittings.
b. Manual volume damper installations.
c. Control-damper installations.
d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
e. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling- mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to ten percent (10%) of amount installed.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653.

1. Galvanized Coating Designation: G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480, Type 304, and having a No. 2 finish for concealed ducts and 1-side bright finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, ¼-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Greenheck Fan Corporation
2. Nailor Industries Inc.
3. Pottorff
4. Ruskin Company

5. Vent Products Co., Inc.

B. Description: Gravity balanced.

C. Maximum Air Velocity:1250 fpm.

D. Maximum System Pressure: 2-inch wg.

E. Frame: Hat-shaped, 0.05-inch-thick, galvanized sheet steel, with welded corners or mechanically attached and mounting flange.

F. Blades: Multiple single-piece blades, maximum 6-inch width, 0.025-inch-thick, roll- formed aluminum with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Neoprene, mechanically locked.

I. Blade Axles:

1. Material: Galvanized steel.
2. Diameter: 0.20-inch.

J. Tie Bars and Brackets: Galvanized steel.

K. Return Spring: Adjustable tension.

L. Bearings: Steel ball or synthetic pivot bushings.

M. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Screen Mounting: Front mounted in sleeve.

a. Sleeve Thickness: 20-gauge minimum.
b. Sleeve Length: 6 inches minimum.

5. Screen Mounting: Rear mounted.
6. Screen Material: Galvanized steel.
7. Screen Type: Bird.
8. 90-degree stops.

2.4 MANUAL VOLUME DAMPERS

A. Manual Volume Dampers: Round.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. McGill AirFlow LLC
b. Pottorff
c. Nailor
d. Ruskin Company

e. Greenheck Fan Corp.

2. Suitable for horizontal or vertical applications.
3. Construction:

a. Frame: 20-gauge galvanized steel with stiffening beads.
b. Blades: 16-gauge galvanized steel.
c. Drive Shaft/Axle: 3/8-inch minimum square drive.
d. Quadrant: Plated steel with hand locking quadrant.

4. Bearings: Synthetic.
5. Accessories: Hand quadrant standoff bracket, minimum of 2 inches for duct insulation installation.

B. Manual Volume Dampers: Low leakage rectangular.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. McGill AirFlow LLC
b. Pottorff
c. Nailor
d. Ruskin Company
e. Greenheck Fan Corp.

2. Construction:

a. Flanged Frame: 13-gauge galvanized steel hat channels.
b. Blades: 16-gauge galvanized steel.

1) Multiple or single blade.

a) For multiple blades linkage concealed in frame.
b) Parallel- or opposed-blade design for multiple blades.

2) Stiffen damper blades for stability.

c. Drive Shaft/Axle: ½-inch minimum diameter.

1) Factory installed jackshaft for multiple section damper.

d. Quadrant: Manual locking quadrant.

3. Bearings: Synthetic.
4. Accessories: Quadrant standoff bracket, minimum of 2 inches for duct insulation installation.

C. Aluminum, Manual Volume Dampers: Rectangular.

1. Comply with AMCA 500-D testing for damper rating.
2. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
3. Suitable for horizontal or vertical applications.
4. Frames: Hat shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Roll-Formed Aluminum Blades: 0.10-inch-thick aluminum sheet.
    d. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.

6. Blade Axles: Stainless-steel.
7. Bearings:

    a. Molded synthetic.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Blade Seals: Neoprene.
9. Jamb Seals: Cambered aluminum.
10. Tie Bars and Brackets: Aluminum.
11. Accessories:

    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

12. Jackshaft:

    a. Size: 1-inch diameter.
    b. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
    c. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

13. Damper Hardware:

    a. Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a ¾-inch hexagon locking nut.
    b. Include center hole to suit damper operating-rod size.
    c. Include standoff bracket to accommodate up to 3-inch-thick insulation.

2.5 CONTROL DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    1. Greenheck Fan Corporation
    2. Nailor Industries Inc.
    3. Pottorff
    4. Ruskin Company

B. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

C. Frames:

    1. Hat-shaped.
    2. 0.094-inch-thick, galvanized sheet steel.
    3. Mitered and welded corners.

D. Blades:

1. Multiple blade with maximum blade width of 8 inches.
2. Parallel- and opposed-blade design.
3. Galvanized steel.
4. 0.064-inch-thick single skin or 0.0747-inch-thick dual skin.
5. Blade Edging: Closed-cell neoprene.
6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

E. Blade Axles: ½-inch-diameter; galvanized steel; blade-linkage hardware of zinc- plated steel and brass; ends sealed against blade bearings.

1. Operating Temperature Range: From minus 40 to plus 200 deg F.

F. Bearings:

1. Oil-impregnated bronze, molded synthetic, oil-impregnated stainless-steel sleeve, or stainless-steel sleeve.
2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
3. Thrust bearings at each end of every blade.

2.6 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Hardcast, Inc.
4. Nexus PDQ
5. Ward Industries; a brand of Hart & Cooley, Inc.

B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

2.7 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Aero-Dyne Sound Control Co.
2. CL WARD & Family Inc.
3. Ductmate Industries, Inc.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

E. Vane Construction: Double wall.

2.8 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Aire Technologies
2. CL WARD & Family Inc.
3. Ductmate Industries, Inc.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA’s “HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

a. Double wall, rectangular.
b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. Vision panel.
d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:

a. Access Doors Less Than 12 Inches Square: No hinges and two (2) sash locks.
b. Access Doors up to 18 Inches Square: Two (2) hinges and two (2) sash locks.
c. Access Doors up to 24 by 48 Inches: Three (3) hinges and two (2) compression latches with outside and inside handles.
d. Access Doors Larger Than 24 by 48 Inches: Four (4) hinges and two (2) compression latches with outside and inside handles.

C. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.
2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Factory set at 3.0- to 8.0-inch wg.
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch-thick, fibrous-glass or polystyrene-foam board.

2.9 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Duro Dyne Inc.
4. Elgen Manufacturing
5. Ventfabrics, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3½ inches or 5¾ inches wide attached to two (2) strips of 2¾-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd.
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

G. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.

1. Minimum Weight: 16 oz./sq. yd.
2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

H. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor Spring Diameter: Not less than eighty percent (80%) of the compressed height of the spring at rated load.
3. Minimum Additional Travel: Fifty percent (50%) of the required deflection at rated load.
4. Lateral Stiffness: More than eighty percent (80%) of rated vertical stiffness.
5. Overload Capacity: Support two hundred percent (200%) of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of ¼-inch movement at start and stop.

2.10 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Compliance with ASHRAE/IESNA 90.1-2004 includes Section 6.4.3.3.3 - "Shutoff Damper Controls," restricts the use of backdraft dampers, and requires control dampers for certain applications. Install backdraft or control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers according to UL listing.

H. Connect ducts to duct silencers rigidly.

I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream and downstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.

7. At each change in direction and at maximum 50-foot spacing.
8. Upstream and downstream from turning vanes.
9. Upstream or downstream from duct silencers.
10. Control devices requiring inspection.
11. Elsewhere as indicated.

J. Install access doors with swing against duct static pressure.

K. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.
3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

L. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

M. Install flexible connectors to connect ducts to equipment.

N. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

O. Connect diffusers to ducts directly or with maximum 24-inch lengths of flexible duct clamped or strapped in place.

P. Connect flexible ducts to metal ducts with liquid adhesive plus sheet metal screws and tape.

Q. Install duct test holes where required for testing and balancing purposes.

R. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of ¼-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 233346 - FLEXIBLE DUCTS

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. Insulated flexible ducts.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For flexible ducts.

1. Include plans showing locations and mounting and attachment details.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling- mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from installers of the items involved.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."

D. Comply with ASTM E 96, "Test Methods for Water Vapor Transmission of Materials."

2.2 INSULATED FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Flexmaster U.S.A., Inc.
2. JP Lamborn Co.

3. Thermaflex; a Flex-Tek Group company

B. Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene or aluminized vapor- barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.
4. Insulation R-Value: Comply with ASHRAE/IES 90.1 and minimum installed value of R 6.

C. Insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene or aluminized vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 210 deg F.
4. Insulation R-Value: Comply with ASHRAE/IES 90.1 and minimum installed value of R 6.

D. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene or aluminized polyethylene or aluminized vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 210 deg F.
4. Insulation R-Value: Comply with ASHRAE/IES 90.1 and minimum installed value of R 6.

E. Insulated, Flexible Duct: UL 181, Class 0, interlocking spiral of aluminum foil; fibrous-glass insulation; polyethylene or aluminized vapor-barrier film.

1. Pressure Rating: 8-inch wg positive or negative.
2. Maximum Air Velocity: 5000 fpm.
3. Temperature Range: Minus 20 to plus 250 deg F.
4. Insulation R-Value: Comply with ASHRAE/IES 90.1 and minimum installed value of R 6.

2.3 FLEXIBLE DUCT CONNECTORS

A. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

B. Non-Clamp Connectors: Adhesive plus sheet metal screws.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install flexible ducts according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.

C. Connect diffusers to ducts directly or with maximum 24-inch lengths of flexible duct clamped or strapped in place.

D. Connect flexible ducts to metal ducts with liquid adhesive plus tape, or adhesive plus sheet metal screws.

E. Install duct test holes where required for testing and balancing purposes.

F. Installation:

1. Install ducts fully extended.
2. Do not bend ducts across sharp corners.
3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
5. Install flexible ducts in a direct line, without sags, twists, or turns.

G. Supporting Flexible Ducts:

1. Suspend flexible ducts with bands 1½ inches wide or wider and spaced a maximum of 18 inches apart. Maximum centerline sag between supports shall not exceed ½-inch per 12 inches.
2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches o.c.

END OF SECTION 233346

SECTION 233423 - HVAC POWER VENTILATORS

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. Cabinet Inline fans.
   2. In-line centrifugal fans.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.

B. Operating Limits: Classify according to AMCA 99.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:

   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound-power ratings.
   3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   4. Material thickness and finishes, including color charts.
   5. Dampers, including housings, linkages, and operators.
   6. Roof curbs.
   7. Fan speed controllers.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.
   3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

   1. Roof framing and support members relative to duct penetrations.
   2. Ceiling suspension assembly members.
   3. Size and location of initial access modules for acoustical tile.

4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

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

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.8 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.9 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One (1) set for each belt-driven unit.

1.10 DELIVERY, STORAGE AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

PART 2 - PRODUCTS

2.1 CABINET INLINE FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Greenheck Fan Corp.
2. Cook, Loren Company

B. Housing:
   1. Constructed of heavy gauge galvanized steel
   2. Interior shall be lined with 0.5 inches of acoustical insulation
   3. Includes prepunched mounting brackets

C. Fan Wheel:
   1. Forward curved centrifugal wheel
   2. Constructed of calcium carbonate filled polypropylene
   3. Statically and dynamically balanced in accordance to AMCA Standard 204-05

D. Motors:
   1. Motor enclosures shall be open driproof (ODP), opening in the frame body and or end brackets
   2. Motors are permanently lubricated sleeve bearing type to match with the fan load and furnished at the specific voltage and phase
   3. Motor shall be mounted on vibration isolators and be accessible for maintenance
   4. Compatible for use with speed controls
   5. Thermal overload protection

E. Spring Loaded Aluminum Backdraft Damper:
   1. Prevents air from entering back into the building when fan is off
   2. Eliminates rattling or unwanted backdrafts

F. Outlet:
   1. Type of outlet: Square
   2. Field rotatable from horizontal to vertical discharge
   3. Duct collar shall include an aluminum backdraft damper

G. Electrical Requirements: disconnect switch

H. Accessories:

   1. Variable-Speed Controller: Solid-state control to reduce speed from one hundred to less than fifty percent (100-<50%).
   2. Isolation: Rubber-in-shear vibration isolators.

I. Capacities and Characteristics: See Schedule on Drawings.

2.2 IN-LINE CENTRIFUGAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

   1. Greenheck Fan Corp.
   2. Cook, Loren Company

B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Drive Units:

1. Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.
2. Motor shall be an electronic commutation (EC) motor. Motor shall be permanently lubricated with heavy duty ball bearings to match fan load and prewired to the specific voltage and phase. Internal motor circuitry shall convert AC power supplied to the fan to DC power to operate the motor.
3. Motor shall be speed controllable down to twenty percent (20%) of full speed. Speed shall be controlled by a 0-10VDC signal.
4. Motor shall be a minimum of eighty-five percent (85%) efficient at all speeds.

D. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

E. Accessories:

1. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
2. Companion Flanges: For inlet and outlet duct connections.
3. Fan Guards: ½-by-1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
4. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
5. Isolation: Spring isolators.
6. Motorized Dampers: Parallel-blade dampers mounted in curb base with Belimo electric actuator with end switch; wired to close when fan stops.

F. Capacities and Characteristics: See Schedule on Drawings.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

B. Enclosure Type: Totally enclosed, fan cooled.

2.4 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Support units using restrained spring isolators. Refer to Vibration- and seismic-control devices are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Section 077200 "Roof Accessories" for installation of roof curbs.

D. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

E. Install units with clearances for service and maintenance.

F. Pipe housing drain to nearest drain or shall be provided with splashblock. Drain shall be copper.

G. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

9. Disable automatic temperature-control operators, energize motor, and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

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

D. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 233423

SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

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. Louvered face diffusers.
2. Louvered face/induction vanes diffusers.
3. Perforated grilles.
4. Fixed face registers and grilles.
5. Heavy duty bar grilles.
6. Duct mounted round grilles.

B. Related Requirements:

1. Section 089000 "Louvers and Vents" for fixed louvers and wall vents, whether or not they are connected to ducts.
2. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume- control dampers not integral to diffusers, registers, and grilles.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

1. Samples: For diffusers, registers, and grilles, in manufacturer’s standard sizes to verify color selected.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling 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. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 SQUARE CEILING DIFFUSERS

A. Louvered Face Diffuser:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
    a. Titus
    b. Krueger
    c. MetalAire, Inc.
    d. Price Industries
2. Material: Aluminum.
3. Finish: Baked anodic acrylic paint, color selected by Architect and Owner from manufacturer's entire range.
4. Assembly:
    a. Frame Assembly: A square inlet and a transition piece to facilitate attachment of round duct.
    b. Inner Core Assembly: Consists of fixed deflection louvers available in one-, two-, three- or four-way horizontal discharge patterns.
5. Mounting: Refer to Drawings. The mechanical contractor shall coordinate with the Architectural reflected ceiling plans.
6. Pattern: Refer to Drawings.
7. Accessories:
    a. Factory installed R-6 foil-backed insulation.

B. Louvered Face/Induction Vanes Diffuser:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
    a. Titus
    b. Krueger
    c. MetalAire, Inc.
    d. Price Industries
2. Material: Aluminum.
3. Finish: Baked anodic acrylic paint, color selected by Architect and Owner from manufacturer's entire range.
4. Assembly:
    a. Frame Assembly: A square inlet and a transition piece to facilitate attachment of round duct.
    b. Inner Core Assembly: Consists of fixed deflection louvers with induction vanes for exceptional mixing.

5. Mounting: Refer to Drawings. The mechanical contractor shall coordinate with the Architectural reflected ceiling plans.
6. Pattern: Refer to Drawings.
7. Accessories:

    a. Factory installed R-6 foil-backed insulation.

2.2 REGISTERS AND GRILLES

A. Perforated Ceiling Return Grille:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Titus
    b. Krueger
    c. MetalAire, Inc.
    d. Price Industries

2. Finish: Baked anodic acrylic paint, color selected by Architect and Owner from manufacturer's entire range.
3. Face Style: Flush.

    a. Aluminum.
    b. Perforated face with 3/16-inch diameter holes on ¼-inch staggered centers and not less than fifty-one percent (51%) free area.

4. Backpan: One-piece stamped heavy gauge steel.

    a. Square connection. Refer to Drawings for sizes.

5. Mounting: Refer to Drawings. The mechanical contractor shall coordinate with the Architectural reflected ceiling plans.

B. Return Grille:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Titus
    b. Krueger
    c. MetalAire, Inc.
    d. Price Industries

2. Material: Aluminum.
3. Fixed Displacement Blades:

    a. Blade deflection angle shall be available at 35°.
    b. Parallel to the long or short dimension of the grille. Refer to Drawings.

4. Construction:

    a. Extruded aluminum with a 1¼-inch-wide border on all sides.

b. Minimum border thickness shall be 0.040- to 0.050-inch.
c. Sizes 24 x 24 inches and smaller shall be constructed using a roll-formed frame.

5. Finish: Baked anodic acrylic paint, color selected by Architect and Owner from manufacturer's entire range.
6. Mounting: Refer Drawings.

C. Heavy-Duty Return Bar Grille:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. MetalAire Inc.
b. Krueger
c. MetalAire, Inc.
d. Price Industries

2. Material: Aluminum.
3. Blade:

a. 0.666-inch bar spacing and 0° deflection angle.
b. Parallel to the long or short dimension of the grille. Refer to Drawings.

4. Construction:

a. Aluminum with a 1-1/4-inch border with on all sides.
b. Bars shall be reinforced by perpendicular support bars.
c. Screw holes shall be countersunk.

5. Minimum border thickness shall be 16 gauge.
6. Sizes 24 x 24 inches and smaller shall be constructed using a roll-formed frame.
7. Finish: Baked anodic acrylic paint, color selected by Architect and Owner from manufacturer's entire range.
8. Mounting: Refer to Drawings.

2.3 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713

SECTION 233723 - HVAC GRAVITY VENTILATORS

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. Gravity intake and relief ventilators.

1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: Ventilators shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of ventilator components, noise or metal fatigue caused by ventilator blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.

B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes, without buckling, opening of joints, overstressing of components, failure of connections, or other detrimental effects.

C. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1-2004.

1.4 ACTION SUBMITTALS

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

B. Shop Drawings: For gravity ventilators. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.

1. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Roof framing plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members to which roof curbs and ventilators will be attached.
2. Sizes and locations of roof openings.

1.6 QUALITY ASSURANCE

A. Performance Ratings: Conform to AMCA standard 211 and 311. Fans must be tested in accordance with ANSI/AMCA Standard 210-99 and AMCA Standard 300-96 in an AMCA

accredited laboratory. Fans shall be certified to bear the AMCA label for air and sound performance seal.

1.7 DELIVERY AND STORAGE

A. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer, material, products included, and location of installation.

B. Storage: Store materials in a dry area indoor, protected from damage, and in accordance with manufacturer's instructions. For long term storage follow manufacturer's Installation, Operations, and Maintenance Manual.

C. Handling: Handle and lift fans in accordance with the manufacturer's instructions. Protect materials and finishes during handling and installation to prevent damage. Follow all safety warnings posted by the manufacturer.

1.8 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 LOW PROFILE RELIEF AND INTAKE GRAVITY VENTILATOR

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Greenheck Fan Corp.
2. Loren Cook Company

B. General Description:

1. Ventilator shall be low silhouette.
2. Selection based on ducted applications.

C. Hood and Base:

1. Material Type: Aluminum.
2. Hood constructed of precision formed, arched panels with interlocking seams.
3. Vertical end panels are fully locked into hood end panels.
4. Base height is standard of 5 inches.
5. Curb cap is 6 inches larger than throat size.
6. Curb cap has pre-punched mounting holes for installation.

D. Bird Screen:

1. Constructed of ½-inch aluminum mesh.
2. Mounted horizontally across the intake and relief area of the hood.

E. Hood Support:

1. Constructed of galvanized steel and fastened so the hood can either be removed completely from the base.

F. Roof Curbs:

1. Type: Pitched. Coordinate with roof slope.
2. Mounted onto roof.
3. Material: Aluminum.
4. Insulation Thickness: 2 inches.
5. Coating Type: Baked enamel.

a. Color to match the roof color.

G. Curb Seal:

1. Rubber seal between fan and the roof curb.

H. Insect Screen:

1. Constructed of fine mesh aluminum
2. Fitted to the top of the throat and prevents entry of insects.

I. Tie-Down Points:

1. Four (4) aluminum brackets located on hood supports, secures fan in heavy wind applications.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.

B. Install gravity ventilators with clearances for service and maintenance.

C. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

D. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Section 079200 "Joint Sealants" for sealants applied during installation.

E. Label gravity ventilators according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

F. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

G. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories.

END OF SECTION 233723

SECTION 236200 - PACKAGED COMPRESSOR AND CONDENSING UNIT

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 packaged, refrigerant compressor and condenser units.

1.1 SUBMITTALS

A. Product Data: Literature shall be provided that indicates dimensions, operating and shipping weights, capacities, ratings, factory supplied accessories, electrical characteristics, and connection requirements. Installation, Operation and Maintenance manual with startup requirements shall be provided.

B. Shop Drawings: Unit drawings shall be provided that indicate assembly, unit dimensions, construction details, clearances, and connection details. Wiring diagram shall be provided with details for both power and control systems and differentiate between factory installed and field installed wiring.

1.2 DELIVERY, STORAGE AND HANDLING

A. Units shall be shipped on a wooden pallet with skeleton crating prior to shipment with doors bolted shut to prevent damage during transport and thereafter while in storage awaiting installation.

B. Follow Installation, Operation and Maintenance manual instructions for rigging, moving, and unloading the unit at its final location.

C. Units shall be stored in a clean, dry place protected from construction traffic in accordance with the Installation, Operation and Maintenance manual.

1.3 QUALITY ASSURANCE

A. Unit shall be certified in accordance with UL Standard 1995/CSA C22.2 No. 236, Safety Standard for Heating and Cooling Equipment.

B. Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration.

C. System Seasonal Energy Efficiency Ratio/Energy Efficiency Ratio (SEER/EER) shall be equal to or greater than prescribed by ASHRAE 90.1, Energy Efficient Design of New Buildings except Low-Rise Residential Buildings.

D. Unit shall be safety certified by ETL and be ETL US and ETL Canada listed. Unit nameplate shall include the ETL/ETL Canada label.

1.4 COORDINATION

A. Coordinate installation of equipment supports.

B. Coordinate location of piping and electrical rough-ins.

1.5 WARRANTY

A. Manufacturer shall provide a limited “parts only” warranty for a period of 12 months from the date of equipment startup or 18 months from the date of original equipment shipment from the factory, whichever is less. Warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided manufacturer’s written instructions for installation, operation and maintenance have been followed. Warranty excludes parts associated with routine maintenance and refrigerant.

B. Compressors shall carry a 5 year warranty from date of original equipment shipment from the factory.

PART 2 - PRODUCTS

2.1 COMPRESSOR AND CONDENSER UNITS, AIR COOLED, 1 TO 5 TONS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
1. Aaon, Inc.

B. Substitute equipment may be considered for approval that includes at a minimum:
1. R-410A refrigerant
2. Hinged access doors with lockable handles
3. Variable capacity compressor with 10-100% capacity
4. 2,500 hour salt spray tested exterior corrosion protection
5. Designed, engineered, and manufactured in the United States of America
6. All other provisions of the specifications must be satisfactorily addressed

C. General Description:
1. Air-Source heat pump condensing units shall include compressors, air-cooled condenser coils, condenser fans, suction and liquid connection valves, accumulator, receiver, reversing valve, filter driers with check valves, and thermal expansion valves.
2. Units shall be factory assembled and tested including leak testing of the coil and run testing of the completed unit. Run test report shall be supplied with the unit in the control compartment.
3. Units shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
4. Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components.
5. Installation, Operation and Maintenance manual shall be supplied within the unit.
6. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment’s access door.
7. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment’s access door.

D. Construction:
1. Units shall be completely factory assembled, piped, and wired and shipped in one section.

2. All cabinet walls, access doors, and roof shall be fabricated of G90 galvanized steel panels.
3. Units shall be specifically designed for outdoor application.
4. Access to compressors and control components shall be through hinged access doors with quarter turn, lockable handles.
5. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.
6. Units shall include forklift slots.

E. Electrical:
1. Unit shall be provided with standard power block for connecting power to the unit.
2. Control circuit transformer and wiring shall provide 24 VAC control voltage from the line voltage provided to the unit.
3. Units shall have a 5kAIC SCCR.
4. Air-source heat pumps shall include an optimized start defrost cycle to prevent frost accumulation on the outdoor coil during heat pump heating operation and to minimized defrost cycle energy usage. If the temperature of the outdoor heat exchanger and/or the suction line is less than a predetermined value, a deferred defrost cycle is initiated wherein the defrost cycle starts after a variable, continuously optimizing, time interval has elapsed. The defrost cycle is terminated when the relative temperatures of the outdoor heat exchanger and/or the suction line indicate that sufficient frost is melted from the heat exchanger to insure adequate time between successive defrost cycles for optimizing the efficiency and reliability of the system, or after a predetermined time interval has elapsed, whichever condition occurs first. During defrost cycle all compressors shall energize, reversing valves shall energize, and auxiliary heat shall energize.
5. Units shall be provided with factory installed and factory wired, non-fused disconnect switch.
6. Units shall be provided with factory installed and factory wired 115V, 12 amp GFI outlet in the unit control panel.

F. Refrigeration System
1. Units shall be provided with one independently circuited R-410A variable capacity scroll compressor with thermal overload protection. Variable capacity scroll compressor shall be capable of modulation from 10-100% of its capacity.
2. Each compressor shall be furnished with a crankcase heater.
3. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged access doors shall provide access to the compressors.
4. Compressors shall be isolated from the base pan with the compressor manufacturer's recommended rubber vibration isolators, to reduce any transmission of noise from the compressors into the building area.
5. Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low pressure sides, and service valves for liquid and suction connections. Liquid line filter driers shall be factory provided and installed. Field installed refrigerant circuits shall include the low side cooling components, refrigerant, thermal expansion valve, liquid line, insulated hot gas reheat line, and insulated suction line.
6. Units shall include a factory holding charge of R-410A refrigerant and oil. Adjusting the charge of the system will be required during installation.
7. Refrigeration circuit shall be provided with modulating hot gas reheat valve, electronic controller, liquid line receiver, supply air temperature sensor and a dehumidification control signal terminal that enables the dehumidification mode of operation, and includes supply air temperature control to prevent supply air temperature swings and overcooling of the space. The matching indoor air handler must include a hot gas reheat coil and a check valve on the hot gas reheat line.

8. Units shall be configured as an air-source heat pump. Refrigeration circuit shall be equipped with a bi-flow liquid line filter drier, reversing valve, suction line accumulator, liquid line receiver, and thermal expansion valve with internal check valve. Reversing valve shall de-energize during the heat pump heating mode of operation. The matching indoor air handler must include a thermal expansion valve with internal check valve.
9. The factory installed controls shall include a 3 minute off delay timer to prevent compressor short cycling. The controls shall also include an adjustable, 20 second delay timer for each additional capacity stage to prevent multiple capacity stages from starting simultaneously and adjustable compressor lock out.
10. Units shall be provided with a suction pressure transducer on the refrigeration circuit.
11. Each compressor shall be provided with a compressor sound blanket.

G. Fans
1. Condenser fan shall be horizontal discharge, axial flow, direct drive fans.
2. Condensing units shall be provided with an electrically commutated motor (ECM) condenser fan, condenser head pressure controller, and discharge pressure transducers for modulating head pressure control to allow cooling operation down to 35°F. Fan motor shall be weather protected, single phase, direct drive, and totally enclosed air over (TEAO) with electronic protection.

H. Coils
1. Coils shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.
2. Coils shall be designed for a minimum of 10°F of refrigerant sub-cooling.
3. Coils shall be hydrogen leak tested.

I. Capacities and Characteristics: See schedule sheet.

2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of compressor and condenser units.

B. Examine roughing-in for refrigerant piping systems to verify actual locations of piping connections before equipment installation.

C. Examine walls, floors, and roofs for suitable conditions where compressor and condenser units will be installed.

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

3.2 INSTALLATION

A. Install unit level and plumb, firmly anchored in locations indicated.

B. Install roof-mounting units on equipment supports specified in Section 077200 "Roof Accessories."

C. Equipment Mounting:

1. Install compressor and condenser units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Division 3.
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

3.3 CONNECTIONS

A. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

B. Connect precharged refrigerant tubing to unit's quick-connect fittings. Install tubing so it does not interfere with access to unit. Install furnished accessories.

C. Connect refrigerant piping to air-cooled compressor and condenser units; maintain required access to unit. Install furnished field-mounted accessories. Refrigerant piping and specialties are specified in Section 232300 "Refrigerant Piping."

D. Connect refrigerant to condenser units. Refrigerant piping and specialties are specified in Section 232300 "Refrigerant Piping" and condenser-water piping. Install shutoff valve and union or flange at each water supply connection; install balancing valve and union or flange at each return connection.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust 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. Certify compliance with test parameters.
2. Leak Test: After installation, charge system with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor operation and unit operation, product capability, and compliance with requirements.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Verify proper airflow over coils.

C. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

D. Compressor and condenser units will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

a. Inspect for physical damage to unit casing.
b. Verify that access doors move freely and are weathertight.
c. Clean units and inspect for construction debris.
d. Verify that all bolts and screws are tight.
e. Adjust vibration isolation and flexible connections.
f. Verify that controls are connected and operational.

B. Lubricate bearings on fan motors.

C. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.

D. Adjust fan belts to proper alignment and tension.

E. Start unit according to manufacturer's written instructions and complete manufacturer's startup checklist.

F. Measure and record airflow and air temperature rise over coils.

G. Verify proper operation of condenser capacity control device.

H. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

I. After startup and performance test, lubricate bearings.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain compressor and condenser units. Refer to Section 017900 “ Demonstration and Training”.

END OF SECTION 236200

SECTION 237220 – AIR TO AIR ENERGY RECOVERY VENTILATOR

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 Air-to-Air Energy Recovery Ventilators for indoor installation.

B. Within this document, these units may be referred to as Energy Recovery Ventilator (ERV) for brevity.

1.3 Related Requirements:

1. Drawing and general provisions of the contract, including General Requirements Division 01, Division 23, Division 23 Specifications Sections, and common work requirements for HVAC apply to work specified in this section.
2. Section 23 09 23: Direct Digital Control System for HVAC.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.5 SUBMITTALS

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

B. Shop Drawings: For air-to-air energy recovery equipment. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For air-to-air energy recovery equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of air-to-air energy recovery equipment.

2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which equipment or suspension systems will be attached.

B. Seismic Qualification Certificates: For air-to-air energy recovery equipment, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: one set of each type of filter specified.

1.9 QUALITY ASSURANCE

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

B. ARI Compliance:

1. Capacity ratings for air-to-air energy recovery equipment shall comply with ARI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment."
2. Capacity ratings for air coils shall comply with ARI 410, "Forced-Circulation Air- Cooling and Air-Heating Coils."

C. ASHRAE Compliance:

1. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."

D. UL Compliance:

1. Packaged heat recovery ventilators shall comply with requirements in UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Nonducted Heat Recovery Ventilators."
2. Electric coils shall comply with requirements in UL 1995, "Heating and Cooling Equipment."

1.10 COORDINATION

A. Coordinate layout and installation of air-to-air energy recovery equipment and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

1.11 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Packaged Energy Recovery Units: two years.

PART 2 - PRODUCTS

A. Manufacturer
1. Available Manufacturers: Subject to compliance with specifications contained within this document, manufacturers offering products that may be incorporated into the work include, but are not limited to:
   a. RenewAire
2. Manufacturer should be in business for minimum 10 years manufacturing energy recovery ventilators.

B. Manufactured Units
1. Air-to-Air Energy Recovery Ventilators shall be fully assembled at the factory and consist of a fixed-plate cross-flow heat exchanger with no moving parts, an insulated double wall painted 20-gauge steel cabinet, motorized outside air intake damper, filter assemblies for both intake and exhaust air, enthalpy core, supply air blower assembly, motorized return air damper, bypass damper, exhaust air blower assembly and electrical control box with all specified components and internal accessories factory installed and tested and prepared for single-point high voltage connection. Entire unit with the exception of field-installed components shall be assembled and test operated at the factory.

C. Cabinet
1. Materials: Formed double wall insulated metal cabinet, fabricated to permit access to internal components for maintenance.
2. Outside casing: Painted components as supplied by the factory shall have polyester urethane paint on 20 gauge G90 galvanized steel.

3. Access doors shall be hinged with airtight closed cell foam gaskets. Door pressure taps, with captive plugs, shall be provided for cross-core pressure measurement allowing for accurate airflow measurement.
4. Unit shall have factory-installed duct flanges on all duct openings.
5. Cabinet Insulation: Unit walls and doors shall be insulated with 1 inch, 4 pound density, foil/scrim faced, high density fiberglass board insulation, providing a cleanable surface and eliminating the possibility of exposing the fresh air to glass fibers, and with a minimum R-value of 4.3 (hr-ft2-°F/BTU).
6. Enthalpy core: Energy recovery core shall be of the total enthalpy type, capable of transferring both sensible and latent energy between airstreams. Latent energy transfer shall be accomplished by direct water vapor transfer from one airstream to the other, without exposing transfer media in succeeding cycles directly to the exhaust air and then to the fresh air. No condensate drains shall be allowed. The energy recovery core shall be designed and constructed to permit cleaning and removal for servicing. The energy recovery core shall have a ten year warranty. Performance criteria are to be as specified in AHRI Standard 1060.
7. Control center / connections: Energy Recovery Ventilator shall have an electrical control center where all high and low voltage connections are made. Control center shall be constructed to permit single-point high voltage power supply connections to the non-fused disconnect.
8. Passive Frost Control: The ERV core shall perform without condensing or frosting under normal operating conditions (defined as outside temperatures above -10ºF and inside relative humidity below 40%). Occasional more extreme conditions shall not affect the usual function, performance or durability of the core. No condensate drains will be allowed.
9. Motorized Isolation Damper(s): Return Air, Outside Air and Bypass motorized dampers of an AMCA Class I low leakage type shall be factory installed.

D. Blower Section
1. Blower section construction, Supply Air and Exhaust Air: Blower assemblies consist of a 208-230V/1 Phase/ 60 HZ, ECM motor, and a direct driven forward-curved blower.
2. Blower assemblies: Shall be statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and horsepower.

E. Motors
1. Blower motors shall be Premium Efficiency, EISA compliant for energy efficiency. The blower motors shall be totally enclosed (TEFC) and be shall be supplied with factory installed motor starters.
2. Direct drive models shall be EISA-compliant for energy efficiency with open drip proof design and integral thermal protection.

F. Unit Controls
1. Fan control: Terminal strip for EC motors.
2. Bypass economizer control: Differential enthalpy control, 2 position dampers with 100% airflow through the core or 100% airflow bypassing the core. Typical for ERV-1 to 3.
3. Sensors: Dirty filter monitor for both airstreams.
4. Factory-installed microprocessor controller and sensors, Premium ERV controls that:
    a. Comply with requirements in Division 23 Section "Sequence of Operations for HVAC Controls"
    b. Has factory-installed hardware and software to enable the building automation interface via BACnet to monitor, control, and display status and alarms
    c. The microprocessor controller shall be capable of operating at temperatures between -20F to 160F
    d. The microprocessor controller shall be a DIN rail mounting type
    e. Factory-installed microprocessor controller shall come with backlit display that allows menu-driven display for navigation and control of unit

f. The microprocessor controller shall have the ability to communicate with the BAS via Modbus RTU/TCP and BACnet MSTP/IP
g. The microprocessor controller shall have integrated ethernet interface and a web server for displaying unit parameters
h. The microprocessor shall have near field communication (NFC) capability for android devices
i. The microprocessor controller shall have an internal programmable time clock that will allow the user to add up to different occupancy schedules and add holidays
j. The microprocessor control shall be capable of integral diagnostics
k. The microprocessor control shall be capable of IP or SI unit display
l. The microprocessor controller shall have a battery powered clock
m. The microprocessor controller shall at a minimum offer the ability for three modes of determining occupancy: a dry contact, the internal time clock or the BAS
n. A remote user terminal to allow for remote monitoring and adjustment of parameters, allowing ease of control access without going outdoors or into the mechanical room if desired by the user
o. The microprocessor controller shall have at a minimum (10) universal inputs/outputs (AI, DI, AO) and have (6) six relay outputs (DO)
p. The microprocessor controller shall have an integrated fieldbus port
q. The microprocessor controller shall have the capability for I/O expansion
r. The microprocessor controller shall have a micro USB port to load the application program, the unit parameters, saving logs, etc.
s. The sensors that will be required for control are:
    1) (2) Temperature sensor for fresh air and exhaust air
    2) (2) Temperature and humidity sensor for outside air, return air
    3) (2) Differential pressure sensors for filter alarms
    4) [(2) Differential pressure sensors for measuring pressure drop across energy recovery core and for determining airflow in both airstreams]
    5) (2) Adjustable current switches

5. The microprocessor controller shall have the capability to monitor the unit conditions for alarm conditions. Upon detecting an alarm, the microprocessor controller shall have the capability to record the alarm description, time, date, available temperatures, and unit status for user review. A digital output shall be reserved for remote alarm indication. Alarms to be also communicated via BAS as applicable. Provide the following alarm functions:
    a. Outside air temperature sensor alarm
    b. Outside air humidity sensor alarm
    c. Return air temperature sensor alarm
    d. Return air humidity sensor alarm
    e. Fresh air sensor alarm
    f. Exhaust air sensor alarm
    g. Dirty filter alarm
    h. Supply and exhaust air proving alarm
    i. Outside airflow sensor alarm
    j. Exhaust airflow sensor alarm
6. Display the following on the face of microprocessor controller:
    a. Unit on
    b. Unit economizer/bypass mode
    c. Outdoor air temperature
    d. Outdoor air humidity
    e. Return air temperature
    f. Return air humidity
    g. Supply air temperature
    h. Unit on/off
    i. Fan on/off
    j. Damper status

k. Alarm digital display

7. The microprocessor controller shall have factory pre-programmed multiple operating sequences for control of the ERV. Factory default settings shall be fully adjustable in the field.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before energy-recovery ventilator installation. Replace with new insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in of plumbing, electrical and HVAC services to verify actual location and compliance with unit requirements. See unit IOM.

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

3.2 INSTALLATION

A. Installation shall be accomplished in accordance with these written specifications, project drawings, manufacturer’s installation instructions as documented in manufacturer’s IOM, Best Practices and all applicable building codes.

B. Install unit with clearances for service and maintenance.

C. Equipment Mounting:
1. Comply with requirements for vibration-isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Comply with requirements for vibration-isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

D. Install units with clearances for service and maintenance.

E. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

3.3 DUCTWORK CONNECTIONS

A. Comply with requirements for ductwork according to Section 233113 "Metal Ducts."

B. Connect duct to units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.4 ELECTRICAL CONNECTIONS

A. Install electrical devices furnished with units but not factory mounted.

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.6 FIELD QUALITY CONTROL

A. Contractor to inspect field assembled components and equipment installation, to include electrical and piping connections. Report results to Architect/Engineer in writing. Inspection must include a complete startup checklist to include (as a minimum) the following: Completed Start-Up Checklists as found in manufacturer’s IOM.

3.7 STARTUP SERVICE

A. Contractor to perform startup service. Clean entire unit install clean filters. Measure and record electrical values for voltage and amperage. Refer to Division 23 “Testing, Adjusting and Balancing” and comply with provisions therein.

3.8 ADJUSTING

A. Adjust initial temperature and humidity setpoints.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.9 DEMONSTRATION

A. Contractor to train owner’s maintenance personnel to adjust, operate and maintain the entire energy recovery ventilator. Refer to Division 01 Section Closeout Procedures and Demonstration and Training.

PART 4 - SEQUENCE OF OPERATION

4.1 DDC CONTROLLER

A. Controller with integral LCD readout for changing set points and monitoring unit operation.

B. Provided with required sensors and programming.

C. Factory programmed, mounted, and tested.

D. Integral USB and Ethernet ports for updating programs and retrieving log files.

4.2 BAS INTERFACE:

A. BACnet MS/TP

4.3 GENERAL OPERATION:

A. POWER UP
1. When the unit main disconnect is closed a delay of 10 seconds (adjustable) occurs for the controller to come online.

B. ERV UNIT START COMMAND
1. An input signal is required to enable the unit operation. The unit will be commanded on by:
    a. Digital input
    b. BAS command
    c. Enable via controller display

C. All types of input that are enabled must be true before the unit will start.
1. The exhaust fan starts after a 3 second delay (adjustable). The exhaust fan will not start until the damper actuator end switch closes.
2. The supply fan starts after a 6 second delay (adjustable). The supply fan will not start until the damper actuator end switch closes.
3. The supply fan, exhaust fan, [economizer], [heating] are controlled based on the chosen unit operating modes and air conditions.

D. ERV UNIT STOP COMMAND (OR DE-ENEGIZED):
1. The unit can then be commanded off by:
    a. Digital input
    b. BAS command
    c. Disable via controller display
2. Supply fan and exhaust fan are de-energized.
3. All dampers are unpowered and spring return to their default position after a 10 second delay (adjustable).

E. SUPPLY FAN OPERATION
1. The supply fan will operate at a constant speed.
2. The unit will attempt to start the supply fan when the supply fan delay timer expires. When the supply fan starts the supply fan adjustable current switch should close and remain closed until the fan is turned off.

F. SUPPLY FAN STATUS
1. Once the supply fan current switch closes, operation is allowed. After a delay of 90 seconds (adjustable) from supply fan start signal, if the supply fan current switch is still open the supply fan alarm should be set to true and operation shall be prohibited. The supply fan status shall be set to true only when the supply fan output is on and supply fan current switch is closed. The supply fan status shall be false in all other circumstances.

G. SUPPLY AIR FLOW CONTROL:
1. The controller will adjust the supply fan ECM command to maintain the supply air flow rate at a set point. The supply air flow rate set point is entered and adjusted from the unit controller display [or provided by the BMS]. The minimum and maximum values for supply air flow rate set point are unit dependent. An adjustable PI (proportional & integral) loop will compare the measured supply air flow to the air flow rate set point and adjust the fan speed. If the measured supply air flow rate varies from the desired air flow rate by more than 10% (adjustable) for more than 60 seconds (adjustable) a supply air flow rate alarm will be set to true. This supply fan operation mode can be used to provide a constant supply air flow rate as the unit filters become loaded.

H. EXHAUST FAN OPERATION:
1. The exhaust fan will operate at a constant speed.

I. EXHAUST FAN STATUS:
1. After a delay of 90 seconds (adjustable) from exhaust fan start signal, if exhaust fan current switch is still open the exhaust fan alarm should be set to true. The exhaust fan status shall be set to true only when the exhaust fan output is on and exhaust fan current switch is closed. The exhaust fan status shall be false in all other circumstances.

J. EXHAUST AIR FLOW CONTROL:
1. The controller will adjust the exhaust fan ECM command to maintain the exhaust air flow rate at a set point. The exhaust air flow rate set point is entered and adjusted from the unit controller display [or provided by the BMS]. The minimum and maximum values for the exhaust air flow rate set point are unit dependent. An adjustable PI (proportional & integral) loop will compare the measured exhaust air flow to the air flow rate set point and adjust the fan speed. If the measured exhaust air flow rate varies from the desired air flow rate by more than 10% (adjustable) for more than 60 seconds (adjustable) an exhaust air flow rate alarm will be set to true. This exhaust fan operation mode can be used to provide a constant exhaust air flow rate as the unit filters become loaded.

K. ECONOMIZER (BYPASS) OPERATION:
1. During normal operation the bypass damper shall remain closed and the face damper open to allow full energy recovery. During economizer operation the bypass damper will be open and the face damper will close to bypass the core. The economizer state can be controlled by enthalpy.
2. The economizer will be locked out when:
    a. The outside air enthalpy is greater than return air enthalpy.
    b. The outside air temperature is less than the economizer field adjustable low lockout.

END OF SECTION 237220

SECTION 237313 - INDOOR AIR-HANDLING UNITS

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 indoor air handling unit.

1.3 SUBMITTALS

A. Product Data: For air-handling unit.

1. Include dimensions, operating and shipping weights, rated capacities, fan curves for each unit with specific design operating point noted, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each type and configuration of indoor, basic, air-handling unit.

1. Include plans, elevations, sections, and **attachment** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of indoor, basic air-handling units, as well as procedures and diagrams.
4. Computer generated fan curves for each fan shall be submitted with specific design operation point noted.
5. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

B. Startup service reports.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: **One set for each** air-handling unit.

1.7 DELIVERY, STORAGE AND HANDLING

A. Units shall be on a wooden pallet with skeleton crating prior to shipment to prevent damage during transport and thereafter while in storage awaiting installation.

B. Follow Installation, Operation and Maintenance manual instructions for rigging, moving, and unloading the unit at its final location.

C. Unit shall be handled carefully to avoid damage to components, enclosures and finish.

D. Unit shall be stored in a clean, dry place protected from weather and construction traffic in accordance with Installation, Operation and Maintenance manual instructions.

1.8 WARRANTY

A. Manufacturer shall provide a limited “parts only” warranty for a period of 12 months from the date of equipment startup or 18 months from the date of original equipment shipment from the factory, whichever is less. Warranty shall cover material and workmanship.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.2 MANUFACTURERS

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

1. Aaon
2. Substitute equipment may be considered for approval that includes at a minimum:
   a. R-410A refrigerant
   b. Direct drive supply fans
   c. Double wall cabinet construction

d. Insulation with a minimum R-value of 6.25
e. Double-sloped stainless steel drain pans
f. Hinged access doors with lockable handles
g. All other provisions of the specifications must be satisfactorily addressed

B. General Description
1. Indoor air handling units shall include filters, supply fans, DX evaporator coil, reheat coil, electric heat and unit controls.
2. Unit shall have a draw-through supply fan configuration and discharge air horizontally.
3. Unit shall be shipped in two sections and factory tested including leak testing of the coils and run testing of the supply fans and factory wired system. Run test report shall be supplied with the unit in the control compartment's literature packet, and also available electronically after the unit ships.
4. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
5. Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components.
6. Installation, Operation and Maintenance manual shall be supplied within the unit.
7. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's hinged access door.
8. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's hinged access door.

C. Construction
1. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.
2. Unit insulation shall have a minimum thermal resistance R-value of 6.25. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D1929-11 for a minimum flash ignition temperature of 610°F.
3. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, prevents heat transfer throu
4. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Sealing shall be included between panels and between access doors and openings to reduce air leakage. Piping and electrical conduit through cabinet panels shall include sea
5. Access to filters, cooling coil, reheat coil, heating coil, supply fans, and electrical and controls components shall be through hinged access doors. Stainless steel hinges shall be included on the doors.
6. Access doors shall be flush mounted to cabinetry, with stainless steel removable hinges and quarter-turn, zinc cast lockable handles.
7. Units with a cooling coil shall include sloped 304 stainless steel drain pan. Drain pan connection shall on either side of the unit.
8. Cooling coil shall be mechanically supported above the drain pan by multiple supports that allow drain pan cleaning and coil removal.
9. Units shall be provided with a high condensate level switch that shuts down the unit when a high water level is detected in the drain pan.
10. Units shall include factory wired control panel compartment LED service lights.

D. Electrical
1. Unit shall be provided with an external control panel with separate low voltage control wiring with conduit and high voltage power wiring with conduit between the control panel and the unit. Both side walls of the control panel shall include louvered vents. Control panel shall be field mounted and shall include a piano hinged service access door with tooled entry.
2. Unit shall be provided with standard power block for connecting power to the unit.
3. Unit shall include a factory installed 24V control circuit transformer.

4. Units shall have a 5kAIC SCCR.
5. Units shall include high and low voltage quick connects for easy wiring at installation.

E. Electric Heat Section
1. Units shall include
2. 2 inch double wall electric heat enclosure.
3. Electric heaters shas be provided with KW as specified in the equipment schedule.
4. Electric heaters shall be equipped with an SCR controller to allow full modulation of the installed heaters.
5. Heaters and safeties shall conform to UL requirements.

F. Supply Fans
1. Unit shall include direct drive, unhoused, backward curved, plenum supply fans.
2. Blowers and motor assembly shall be dynamically balance and mounted on rubber isolators.
3. Blower and motor assembly shall utilize neoprene gasket.
4. Motor shall be an IE5 efficiency permanent magnet totally enclosed motor.
5. ECM driven supply fan speed shall be controlled with the factory installed AAON controller.
6. Access to supply fan shall be through an access door with removable pin hinges and lockable quarter turn handles.

G. Cooling Coil
1. Evaporator Coil
   a. Coils shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and galvanized steel end casings. Fin design shall be sine wave rippled.
   b. Coils shall be 6 row high capacity and 10 fins per inch.
   c. Coils shall be helium leak tested.
   d. Coils shall be furnished with factory installed thermostatic expansion valves.The sensing bulbs shall be field installed on the suction line immediately outside the cabinet.
   e. Coils shall have external piping connections. Coordinate in field. Liquid and suction connections shall be sweat connection. Coil connections shall be labeled, extend beyond the unit casing, and be factory sealed with grommets that cover both the interior and exterior.

H. Refrigeration System
1. Air handling unit and matching condensing unit shall be capable of operation as an R-410A split system air conditioner.
2. Each refrigeration circuit shall be equipped with thermostatic expansion valve type refrigerant flow control.
3. Modulating hot gas reheat shall be provided on the refrigeration circuit. Air handling unit shall be provided with hot gas reheat coil, a check valve on the liquid line, and a check valve on the hot gas reheat line. The matching condensing unit must include modulating 3-way reheat valve, liquid line receiver, electronic controller, supply air temperature sensor and a dehumidification control signal terminal. This allows the system to have a dehumidification mode of operation and includes supply air temperature control to prevent supply air temperature swings and overcooling of the space. Reheat line connections shall be labeled, extend beyond the unit casing and be located near the suction and liquid line connections for ease of field connection. Connections shall be factory sealed on both the interior and exterior of the unit casing to minimize air leakage.
4. Unit shall be configured as heat pump. Refrigeration circuit shall be equipped with a thermal expansion with an internal check valve on the indoor coil.
5. Reversing valve, outdoor coil thermal expansion valve, bi-flow filter drier, and liquid line receiver shall be factory installed in the matching AAON condensing unit.

I. Filters
   1. Unit filter access shall be through service access door with piano hinges and quarter turn button fasteners.
   2. Units shall include 4 inch thick, pleated panel filters with a MERV rating of 13, upstream of the cooling coil. Unit shall also include 2 inch thick, pleated panel pre filters with MERV rating of 8, upstream of the 4 inch standard filters.

J. Controls
   1. Unit shall be provided with a proof of airflow switch. When airflow is not detected, the supply fans will shut down.
   2. Unit shall be provided with an external control panel with separate low voltage control wiring with conduit and high voltage power wiring with conduit between the control panel and the unit. Control panel shall be field mounted.
   3. Access to external control panel shall be through hinged access door with tooled entry.
   4. Factory Installed and Factory Provided Controller
      a. Unit controller shall be capable of controlling all features and options of the unit. Controller shall be factory installed in the unit controls compartment and factory tested.
      b. Controller shall be capable of standalone operation with unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling available without dependence on a building management system.
      c. Controller shall have an onboard clock and calendar functions that allow for occupancy scheduling.
      d. Controller shall include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.
      e. Constant Volume Controller
         1) Unit shall modulate cooling with constant airflow to meet space temperature cooling loads.
         2) Unit shall modulate heating with constant airflow to meet space temperature heating loads. Modulating heating capacity shall modulate based on supply air temperature.
      f. Unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling shall be accomplished with connection to interface module with LCD screen and input keypad, interface module with touch screen, or with connection to PC with free configuration software. Controller shall be capable of connection with other factory installed and factory provided unit controllers with individual unit configuration, setpoint adjustment, sensor status viewing, and occupancy scheduling available from a single unit. Connection between unit controllers shall be with a modular cable. Controller shall be capable of communicating and integrating with a BACnet network.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Replace with new insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION, GENERAL

A. Suspended Unit: Suspend unit from structural-steel support frame using threaded steel rods and spring hangers. Coordinate sizes and locations of structural-steel support members with actual equipment provided. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration Controls for HVAC."

B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

D. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4 , ASTM B88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Inspect casing insulation for integrity, moisture content, and adhesion.
2. Verify that clearances have been provided for servicing.
3. Verify that controls are connected and operable.
4. Verify that filters are installed.
5. Inspect and adjust vibration isolators and seismic restraints.
6. Verify bearing lubrication.
7. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.

C. Start unit according to manufacturer's written instructions.

1. Complete startup sheets and attach copy with Contractor's startup report.
2. Inspect and record performance of interlocks and protective devices; verify sequences.
3. Operate unit for run-in period recommended by manufacturer.
4. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
5. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
6. Measure and record airflow. Plot fan volumes on fan curve.
7. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
8. Verify outdoor-air damper operation.

3.7 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within twelve (12) months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two (2) visits to Project during other-than-normal occupancy hours for this purpose.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air handling units.

END OF SECTION 237313

SECTION 238127 - HYPER-HEAT HEAT PUMP SYSTEM

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. Hyper-heat heat pump.

1.3 QUALITY ASSURANCE

A. The system components shall be tested by a Nationally Recognized Testing Laboratory (NRTL) and shall bear the ETL label.

B. All wiring shall be in accordance with the National Electrical Code (N.E.C.).

C. The units shall be rated in accordance with Air-Conditioning, Heating, and Refrigeration Institute's (AHRI) Standard 240 and bear the AHRI Certification label.

D. The units shall be manufactured in a facility registered to ISO 9001 and ISO 14001, which is a set of standards applying to product and manufacturing quality and environmental management and protection set by the International Standard Organization (ISO).

E. A dry air holding charge shall be provided in the indoor section.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Unit shall be stored and carefully handled according to the manufacturer's recommendations.

B. The wireless remote controller, for the wall mounted and floor standing indoor units, shall be shipped inside the carton and packaged with the indoor unit and shall be able to withstand 105°F storage temperatures and ninety-five percent (95%) relative humidity without adverse effect.

C. The remote controller, for the ceiling suspended, ceiling recessed, and ducted indoor units, either wireless or wired, shall be shipped separately.

1.5 WARRANTY

A. The units shall be covered by the manufacturer's limited warranty for a period of one (1) year parts and seven (7) year compressor to the original Owner from date of installation.

B. Manufacturer shall have a minimum of fifteen (15) years continuous experience providing VRF systems in the U.S. market.

C. All manufacturer technical and service manuals must be readily available for download by any local contractor should emergency service be required. Registering and sign-in requirements which may delay emergency service reference are not allowed.

D. The system shall be installed by a Contractor with extensive install and service training. The mandatory Contractor service and install training should be performed by the manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design: Subject to compliance with requirements, provide products by the following:

1. Trane /Mitsubishi

B. Acceptable alternative manufacturers, assuming compliance with these equipment specifications, are Panasonic and Hitachi. Contractor bidding an alternate manufacturer does so with full knowledge that that manufacturers product may not be acceptable or approved and that Contractor is responsible for all specified items and intents of this document without further compensation.

2.2 OUTDOOR UNIT – HYPER-HEAT HEAT PUMP

A. General:

1. The outdoor unit module shall be air-cooled, direct expansion (DX), multi-zone units. The outdoor unit modules shall be equipped with a single compressor which is inverter-driven and multiple circuit boards, all of which must be manufactured by the branded VRF manufacturer. Each outdoor unit module shall be completely factory assembled, piped, and wired and run tested at the factory.
2. If an alternate manufacturer is selected, any additional material, cost, and labor to install additional lines shall be incurred by the Contractor. Contractor is responsible for ensuring alternative brand compatibility in terms of availability, physical dimensions, weight, electrical requirements, etc.
3. Outdoor unit shall have a sound rating no higher than 59 dB(A).
4. Refrigerant lines from the outdoor unit to the indoor units shall be insulated in accordance with the installation manual.
5. The outdoor unit shall have the capability of installing the main refrigerant piping through the bottom of the unit.
6. The outdoor unit shall have an accumulator with refrigerant level sensors and controls.
7. The outdoor unit shall have a high-pressure safety switch, over-current protection, crankcase heater, and DC bus protection.
8. VRF system shall meet performance requirements per schedule and be within piping limitations and acceptable ambient temperature ranges as described in respective manufacturers' published product catalogs. Non-published product capabilities or performance data are not acceptable.
9. The outdoor unit shall be capable of guaranteed operation in heating mode down to -13°F ambient temperatures and cooling mode up to 115°F without additional restrictions on line length and vertical separation beyond those published in respective product catalogs. Models with capacity data for required temperature range published as "for reference only" are not considered capable of guaranteed operation and are not acceptable. If an alternate manufacturer is selected, any additional material, cost, and labor to meet ambient operating range and performance shall be incurred by the Contractor.

10. The outdoor unit shall have a high efficiency oil separator plus additional logic controls to ensure adequate oil volume in the compressor is maintained. Oil return sequences must be enabled only during extended periods of reduced refrigerant flow to ensure no disruption to correct refrigerant flow to individual zones during peak loads. Systems which might engage oil return sequence based on hours of operation risk oil return during inopportune periods are not allowed. Systems which rely on sensors (which may fail) to engage oil return sequence are not allowed.
11. The outdoor unit shall be provided with a manufacturer supplied 20-gauge hot-dipped galvanized snow/hail guard. The snow/hail guard protects the outdoor coil surfaces from hail damage and snow build-up in severe climates.

B. Unit Cabinet:

1. The casing shall be fabricated of galvanized steel, bonderized, finished with an electrostatically applied, thermally fused acrylic or polyester powder coating for corrosion protection. Assembly hardware shall be cadmium plated for weather resistance.
2. Cabinet color shall be Munsell 3Y 7.8/1.1.
3. The outdoor unit shall be tested in compliance with ISO9277 such that no unusual rust shall develop after 960 hours of salt spray testing.
4. Panels on the outdoor unit shall be scratch free at system startup. If a scratch occurs, the salt spray protection is compromised and the panel should be replaced immediately.
5. Two (2) mild steel mounting feet, traverse mounted across the cabinet base pan, welded mount, providing four (4) slotted mounting holes shall be furnished. Assembly shall withstand lateral wind gust up to 155 mph to meet applicable weather codes.

C. Fan:

1. Each outdoor unit module shall be furnished with direct drive, variable speed propeller type fan(s) only.
2. All fan motors shall have inherent protection, have permanently lubricated bearings, and be completely variable speed.
3. All fans shall be provided with a raised guard to prevent contact with moving parts.
4. The outdoor unit shall have horizontal discharge airflow.

D. Refrigerant and Refrigerant Piping:

1. R410A refrigerant shall be required for systems.
2. Polyolester (POE) oil – widely available and used in conventional domestic systems – shall be required. Prior to bidding, manufacturers using alternate oil types shall submit material safety data sheets (MSDS) and comparison of hygroscopic properties for alternate oil with list of local suppliers stocking alternate oil.
3. Refrigerant piping shall be phosphorus deoxidized copper (copper and copper alloy seamless pipes) of sufficient radial thickness as defined by the equipment manufacturer and installed in accordance with manufacturer recommendations.
4. All refrigerant piping must be insulated with ½-inch closed cell, CFC-free foam insulation with flame-spread Index of less than 25 and a smoke-development Index of less than 50 as tested by ASTM E 84 and CAN/ULC S-102. R value of insulation must be at least 3.
5. Refrigerant piping limits shall be in accordance with manufacturer specifications.

E. Coil:

1. The outdoor unit coil shall be of nonferrous construction with lanced or corrugated plate fins on copper tubing.
2. The coil fins shall have a factory applied corrosion resistant blue-fin finish.
3. The coil shall be protected with an integral guard.

4. Refrigerant flow from the outdoor unit shall be controlled by means of an inverter driven compressor.

F. Compressor:

1. The outdoor unit module shall be equipped with only inverter driven scroll hermetic compressors. Non-inverter-driven compressors, which may cause inrush current (demand charges) and require larger generators for temporary power shall not be allowed.
2. Crankcase heat shall be provided via induction-type heater utilizing eddy currents from motor windings. Energy-wasting “belly-band” type crankcase heaters are not allowed.
3. Compressor shall have an inverter to modulate capacity.
4. The compressor shall be equipped with an internal thermal overload.

G. Basepan Heater: Each outdoor unit module shall be equipped with a basepan heater to protect the coil against ice build-up during prolonged winter operation. Basepan heater shall activate only if compressor is operating in heating mode at an outdoor ambient temperature of 36F or below.

H. Controls: The unit shall be an integral part of the system and control network described in Article 2.4 (SYSTEM CONTROL) and react to heating/cooling demand as communicated from connected indoor units over the control circuit. Required field-installed control voltage transformers and/or signal boosters shall be provided by the manufacturer.

I. Electrical:

1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
2. The unit shall be capable of satisfactory operation within voltage limits of 198 volts to 253 volts.
3. The outdoor unit shall be controlled by the microprocessors located in the indoor unit and in the outdoor unit communicating system status, operation, and instructions digitally over A-Control – a system directing that the indoor unit be powered directly from the outdoor unit using a 3-wire, 14-gauge AWG connection plus ground.
4. The outdoor unit shall be equipped with Pulse Amplitude Modulation (PAM) compressor inverter drive control for maximum efficiency with minimum power consumption.

2.3 DUCTED INDOOR UNIT

A. General: The ceiling-concealed ducted indoor unit shall be factory assembled, wired, and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board, and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, and an auto restart function. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory. The unit shall be suitable for use in plenums in accordance with UL1995 ed 4.

B. Unit Cabinet:

1. The unit shall be ceiling-concealed, ducted, with a 2-position, field adjustable return and a fixed horizontal discharge supply.
2. The cabinet panel shall have provisions for a field installed filtered outside air intake.

C. Fan:

1. Indoor unit shall feature multiple external static pressure settings ranging from 0.14 to 0.60 in. WG.

2. The indoor unit fan shall be an assembly with statically and dynamically balanced Sirocco fan(s) direct-driven by a single motor with permanently lubricated bearings.
3. The indoor unit shall include an AUTO fan setting capable of maximizing energy efficiency by adjusting the fan speed based on the difference between controller set-point and space temperature. The indoor fan shall be capable of three (3) speed settings, Low, Mid, High plus the Auto-Fan function.

D. Filter Frame and Filter:

1. Filter frame shall be constructed of 20-gauge G-60 galvanized steel. Knurled thumb screws on access door allow filter replacement. Foam gasket provides air-tight connection to indoor unit and access door. Filter frame shall be configurable for rear or bottom return.
2. Filter shall be rated MERV 13 when tested in accordance with ANSI/ASHRAE 52.2 Standard Rated Class 2 under U.L. Standard 900.

E. Coil:

1. The indoor coil shall be of non-ferrous construction with smooth plate fins on copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phos-copper or silver alloy.
2. The coils shall be pressure tested at the factory.
3. Coil shall be provided with a sloped drain pan. Units without sloped drain pans which must be installed cockeyed to ensure proper drainage are not allowed.
4. The unit shall be provided with an integral condensate lift mechanism able to raise drain water 27 inches above the condensate pan.

F. Electrical:

1. The unit electrical power shall be 208-230 volts, 1-phase, 60 hertz.
2. The system shall be equipped with A-Control – a system directing that the indoor unit be powered directly from the outdoor unit using a 3-wire, 14-gauge AWG connections plus ground.

G. Controls:

1. Indoor unit shall compensate for the higher temperature sensed by the return air sensor compared to the temperature at level of the occupant when in HEAT mode. Disabling of compensation shall be possible for individual units to accommodate instances when compensation is not required.
2. Control board shall include contacts for control of external heat source. External heat may be energized as second stage with 1.8°F–9.0°F adjustable deadband from set point.
3. Indoor unit shall include no less than four (4) digital inputs capable of being used for customizable control strategies.
4. Indoor unit shall include no less than three (3) digital outputs capable of being used for customizable control strategies.
5. Control board shall include contacts for control of no less than two (2) stages of external heat. The first stage of external heat may be energized when the space temperature is 2.7°F from set point for between 10-25 minutes (user adjustable). The second stage of external heat may be energized when the first stage has been active for no less than 5 minutes and the space temperature has not risen by more than 0.9°F.

H. Unit Accessories:

1. Room Temperature Sensors: Allows for remote sensing of space temperature up to 100 ft away from the indoor unit.

2.4 4-WAY CEILING-RECESSED CASSETTE WITH GRILLE FOR 2X2 GRID INDOOR UNIT

A. Description:

1. The indoor unit shall be a four-way cassette style indoor unit that recesses into the ceiling with a ceiling grille. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, an emergency operation function and a test run switch. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory. The unit shall be suitable for use in plenums in accordance with UL1995 ed 4.

B. Unit Cabinet:

1. The cabinet shall be a compact 22-7/16” wide x 22-7/16” deep so it will fit within a standard 24” square suspended ceiling grid.
2. The cabinet panel shall have provisions for a field installed filtered outside air intake.
3. Four-way grille shall be fixed to bottom of cabinet allowing two, three or four-way blow.

C. Fan:

1. The indoor fan shall be an assembly with a turbo fan direct driven by a single motor.
2. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
3. The indoor unit shall include an AUTO fan setting capable of maximizing energy efficiency by adjusting the fan speed based on the difference between controller set-point and space temperature. The indoor fan shall be capable of five (4) speed settings, Low, Mid, High and Auto.
4. The indoor unit shall have an adjustable air outlet system offering 4-way airflow, 3-way airflow, or 2-way airflow.
5. The indoor unit vanes shall have 5 fixed positions and a swing feature that shall be capable of automatically swinging the vanes up and down for uniform air distribution.

D. Filter:

1. Return air shall be filtered by means of a long-life washable filter.

E. Coil:

1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phos-copper or silver alloy.
2. The coils shall be pressure tested at the factory.
3. The unit shall be provided with an integral condensate lift mechanism that will be able to raise drain water 19-3/4” inches above the condensate pan.

F. Electrical:

1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.

2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).

G. Controls:

1. Indoor unit shall compensate for the higher temperature sensed by the return air sensor compared to the temperature at level of the occupant when in HEAT mode. Disabling of compensation shall be possible for individual units to accommodate instances when compensation is not required.
2. Control board shall include contacts for control of external heat source. External heat may be energized as second stage with 1.8°F – 9.0°F adjustable deadband from set point.
3. Indoor unit shall include no less than four (4) digital inputs capable of being used for customizable control strategies.
4. Indoor unit shall include no less than three (3) digital outputs capable of being used for customizable control strategies.
5. A factory-installed drain pan sensor shall provide protection against drain pan overflow by sensing a high condensate level in the drain pan. Should this occur, the control shuts down the indoor unit before an overflow can occur. A thermistor error code will be produced should the sensor activate indicating a fault which must be resolved before the unit re-starts.

H. Unit Accessories:

1. Room Temperature Sensors: Allows for remote sensing of space temperature up to 100 ft away from the indoor unit.

2.5 1-WAY CEILING-RECESSED CASSETTE WITH GRILLE INDOOR UNIT

A. Description:

1. The one-way cassette indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, an emergency operation function and a test run switch. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory. The unit shall be suitable for use in plenums in accordance with UL1995 ed 4.

B. Unit Cabinet:

1. The cabinet panel shall have provisions for a field installed filtered outside air intake.
2. Branch ducting shall be allowed from cabinet.
3. The one-way grille shall be fixed to bottom of cabinet allowing for one-way airflow.

C. Fan:

1. The indoor fan shall be an assembly with one line-flow fan direct driven by a single motor with permanently lubricated bearings.
2. The indoor fan shall consist of four (4) speeds, Low, Mid1, Mid2, and High.

D. Filter:

1. Return air shall be filtered by means of a long-life washable permanent filter.

E. Coil:
1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phos-copper or silver alloy.
2. The coils shall be pressure tested at the factory.
3. The unit shall be provided with an integral condensate lift mechanism able to raise drain water 23 inches above the condensate pan.

F. Electrical:

1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).

G. Controls:
1. Indoor unit shall compensate for the higher temperature sensed by the return air sensor compared to the temperature at level of the occupant when in HEAT mode. Disabling of compensation shall be possible for individual units to accommodate instances when compensation is not required.
2. Control board shall include contacts for control of external heat source. External heat may be energized as second stage with 1.8°F – 9.0°F adjustable deadband from set point.
3. Indoor unit shall include no less than four (4) digital inputs capable of being used for customizable control strategies.
4. Indoor unit shall include no less than three (3) digital outputs capable of being used for customizable control strategies.
5. A factory-installed drain pan sensor shall provide protection against drain pan overflow by sensing a high condensate level in the drain pan. Should this occur the control shuts down the indoor unit before an overflow can occur. A thermistor error code will be produced should the sensor activate indicating a fault which must be resolved before the unit re-starts.

H. Unit Accessories:

1. Room Temperature Sensors: Allows for remote sensing of space temperature up to 100 ft away from the indoor unit.

2.6 SYSTEM CONTROL

A. Electrical Characteristics:

1. General: Controller power and communications shall be via a common non-polar communications bus and shall operate at 30VDC.
2. Wiring: Control wiring shall be installed in a daisy chain configuration from indoor unit to indoor unit, and to the outdoor unit. Control wiring to remote controllers shall be run from the indoor unit terminal block to the controller associated with that unit.
3. Wiring Type: Wiring shall be 2-conductor (16 AWG), twisted, stranded, shielded wire.

B. Remote Controllers:

1. Provide each VRF indoor unit with a backlit wired MA controller. The Wired MA Remote Controller shall be capable of controlling indoor unit.
2. The basic functions are:

Wired Remote Controller

Item	Description	Operation	Display
ON/OFF	Run and stop operation for a single group	Each Group	Each Group
Operation Mode	Switches between Cool/Drying/Auto/Fan/Heat. Operation modes vary depending on the air conditioner unit.	Each Group	Each Group
Temperature Setting	Sets the temperature from 67°F – 87°F depending on operation mode and indoor unit. Separate COOL and HEAT mode set points available depending on central controller and connected mechanical equipment.	Each Group	Each Group
Fan Speed Setting	Available fan speed settings depending on indoor unit.	Each Group	Each Group
Air Flow Direction Setting	Air flow direction settings vary depending on the indoor unit model.	Each Group	Each Group
Permit / Prohibit Local Operation	Individually prohibit operation of each local remote control function (Start/Stop, Change operation mode, Set temperature, Vane, Reset filter). *1: Centrally Controlled is displayed on the remote controller for prohibited functions.	N/A	Each Group *1
Display Indoor Unit Intake Temp	Measures and displays the intake temperature of the indoor unit when the indoor unit is operating.	N/A	Each Group
Display Backlight	Pressing a button lights up a backlight. The light automatically turns off after a certain period of time. (The brightness settings can be selected from Bright, Dark, and Light off.)	N/A	Each Unit
Error	When an error is currently occurring on an air conditioner unit, the afflicted unit and the error code are displayed	N/A	Each Unit
Test Run	Operates air conditioner units in test run mode. *2 The display for test run mode will be the same as for normal start/stop (does not display “test run”).	Each Group	Each Group *2
Ventilation Equipment	Up to 16 indoor units can be connected to an interlocked system that has one LOSSNAY unit.	Each Group	N/A
Set Temperature Range Limit	Set temperature range limit for cooling, heating, or auto mode.	Each Group	Each Group
Schedule	Set up to 8 operations per day, 7 days per week. Operations include time on/off, mode and room temperature set point.	Each Group	Each Group

C. The microprocessor located in the indoor unit shall have the capability of sensing return air temperature and indoor coil temperature, receiving and processing commands from the wired controller, providing emergency operation and controlling the outdoor unit.

2.7 ACCESSORIES

A. Refrigerant Line Sweat Adapter Kit: Provide a sweat adapter kit to permit field brazing of refrigerant line connections.

2.8 CAPACITIES AND CHARACTERISTICS

A. Cooling Capacity: See Schedule on Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units maintaining manufacturer's recommended clearances.

B. Install ground-mounted units on a 4-inch-thick, reinforced concrete base, 4 inches larger than condensing unit on each side. Coordinate installation of anchoring devices.

C. Install roof-mounted units on equipment supports. Anchor unit to supports with removable fasteners.

D. Install units on spring isolators specified in Division 23.

E. Connect pre-charged refrigerant tubing to unit's quick-connect fittings. Install tubing so it does not interfere with access to unit. Install furnished accessories.

F. Connect refrigerant piping to condensing units; maintain required access to unit. Install furnished field-mounted accessories.

3.2 FIELD QUALITY CONTROL

A. Leak Test: After installation, charge systems with refrigerant and oil and test for leaks. Repair leaks and replace lost refrigerant and oil.

B. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.

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

C. Remove and replace malfunctioning units with new units and retest.

END OF SECTION 238127

SECTION 238239.19 – ELECTRIC HEATERS

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 wall mounted heaters with electric-resistance heating coils and electric cove heaters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include details of anchorages and attachments to structure and to supported equipment.
4. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
5. Wiring Diagrams: Power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wall and ceiling unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Indeeco
2. QMark

2.2 WALL HEATER

A. Description:

1. Assembly includes chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.

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

B. Cabinet:

1. Front Panel: Architectural extruded-aluminum grille, with removable panels fastened with tamperproof fasteners.
2. Finish: Manufacturer's baked enamel over baked-on primer in color selected by Architect and Owner from manufacturer's entire range, applied to factory-assembled and -tested wall heaters before shipping.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
4. Surface-Mounted Cabinet Enclosure: Steel with finish to match cabinet.
5. Recessed Mounted Cabinet Enclosure: Steel with finish to match cabinet.

C. Heating Element:

1. Electric: Steel finned tubular elements.

D. Fan and Motor:

1. Fan: Aluminum propeller directly connected to motor.
2. Motor: Permanently lubricated totally enclosed motor.

E. Controls:

1. Built-In Controls:

a. Unit-mounted thermostat, tamperproof.
b. Automatic reset thermal cutout.
c. Overtemperature warning light.
d. Fan Auto/On switch.

F. Electrical:

1. Factory wire motors and controls for a single field connection with disconnect switch.

G. Capacities and Characteristics:

1. Refer to Schedule on Drawings.

2.3 UNIT HEATER

A. Description: An assembly including casing, coil, fan, and motor in horizontal discharge configuration with adjustable discharge louvers.

B. Comply with UL 2021.

C. Comply with UL 823.

D. Cabinet: Removable panels for maintenance access to controls.

E. Cabinet Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heater before shipping. Color as selected by the Architect and Owner from manufacturer's entire range.

F. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

G. Discharge Louver: Adjustable fin diffuser for horizontal units.

H. Electric-Resistance Heating Elements: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16-inch. Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F (288 deg C) at any point during normal operation.

1. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
2. Wiring Terminations: Stainless-steel or corrosion-resistant material.

I. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

J. Fan Motors: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Type: Permanently lubricated, multispeed.

K. Control Devices:

1. Unit-mounted thermostat.

L. Capacities and Characteristics

1. Heating Capacity: Refer to Schedule.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive wall heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for electrical connections to verify actual locations before heater installation.

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

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions and in proper relationship with the adjacent construction.

B. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

3.3 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair, or replace damaged product before substantial completion.

END OF SECTION 238239.19

SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

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. Electrical equipment coordination and installation.
2. Sleeves for raceways and cables.
3. Sleeve seals.
4. Grout.
5. Common electrical installation requirements.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For sleeve seals.

1.5 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping and conduit installed at required slope.
4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."."

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following into the Work include, but are not limited to, the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.

3. Sealing Elements: EPDM and/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.
4. Pressure Plates: Plastic, Carbon steel, Stainless steel. Include two for each sealing element.
5. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating, Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

F. Devices on wall shall be installed on a common vertical center line wherever possible.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inche**s** above finished floor level.

G. Size pipe sleeves to provide 1/2-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants.".

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable

penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

N. Exterior-Wall Penetrations: Seal all penetrations once the demo/remediation is complete.

SLEEVE-SEAL INSTALLATION

O. Install to seal exterior wall penetrations.

P. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.4 COMISSIONING OF EQUIPMENT

A. Engage a factory authorized service representative, who is familiar with this project, to participate and assist, if necessary, in the functional performance testing of the equipment include in this Division with the Commissioning Agent.

END OF SECTION 260500

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.
3. Sleeves and sleeve seals for cables.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

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

B. Qualification Data: For testing agency.

C. Field quality-control test reports.

D. Product Schedule: Indicate type, use, location, and termination locations.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.6 COORDINATION

A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Description: Flexible, insulated, and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Alcan Products Corporation; Alcan Cable Division.
2. American Insulated Wire Corp.; a Leviton Company.
3. General Cable Corporation.
4. Senator Wire & Cable Company.
5. Southwire Company.

C. Aluminum and Copper Conductors: Comply with NEMA WC 70.

D. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN.

E. Multiconductor Cable: Comply with NEMA WC 70 for armored cable, Type AC, metal-clad cable, Type MC, mineral-insulated, and metal-sheathed cable, Type MI with ground wire.

F. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 and ASTM B 496 for stranded conductors.

2.2 CONNECTORS AND SPLICES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. AFC Cable Systems, Inc.
2. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SLEEVES FOR CABLES

A. Steel Pipe Sleeves: ASTM A 53, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.4 SLEEVE SEALS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Advance Products & Systems, Inc.
2. Calpico, Inc.
3. Metraflex Co.
4. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.

1. Sealing Elements: EPDM 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: Plastic, Carbon steel, Stainless steel. Include two (2) for each sealing element.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one (1) for each sealing element.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: All feeders and service entrance cables shall be Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-THWN, single conductors in raceway.

B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

E. Feeders Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway.

F. Feeders in Cable Tray: Type THHN-THWN, single conductors in raceway and metal-clad cable, Type MC.

G. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-THWN, single conductors in raceway.

H. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway and metal-clad cable, Type MC.

I. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

J. Branch Circuits Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway and metal-clad cable, Type MC.

K. Branch Circuits in Cable Tray: Type THHN-THWN, single conductors in raceway and metal-clad cable, Type MC.

L. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

M. Class 1 Control Circuits: Type THHN-THWN, in raceway.

N. Class 2 Control Circuits: Type THHN-THWN, in raceway Power-limited cable, concealed in building finishes, Power-limited tray cable, in cable tray.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."

F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

3.4 CONNECTIONS

A. 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.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Rectangular Sleeve Minimum Metal Thickness:

1. For sleeve rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
2. For sleeve rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.

E. 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.

F. Cut sleeves to length for mounting flush with both wall surfaces.

G. Extend sleeves installed in floors 2 inches above finished floor level.

H. Size pipe sleeves to provide ¼-inch annular clear space between sleeve and cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.

I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."

K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping."

L. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.

M. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

N. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.6 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations

B. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

C. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.7 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.8 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.9 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Perform tests and inspections and prepare test reports.

C. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services for compliance with requirements.
2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Infrared Scanning: After Substantial Completion, but not more than sixty (60) days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.

a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice eleven (11) months after date of Substantial Completion.
b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

D. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

E. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 260519

SECTION 260523 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. UTP cabling.
2. 50/125 and 62.5/125-micrometer, multimode optical fiber cabling.
3. RS-232 cabling.
4. RS-485 cabling.
5. Low-voltage control cabling.
6. Control-circuit conductors.
7. Identification products.

1.3 DEFINITIONS

A. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.

B. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel section.

C. EMI: Electromagnetic interference.

D. IDC: Insulation displacement connector.

E. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).

F. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

G. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).

H. RCDD: Registered Communications Distribution Designer.

I. Solid-Bottom or Nonventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal side rails, and a bottom without ventilation openings.

J. Trough or Ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and using 75 percent or less of the plan area of the surface to support cables.

K. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

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

B. Shop Drawings: For cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:

1. Vertical and horizontal offsets and transitions.
2. Clearances for access above and to side of cable trays.
3. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
4. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

C. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.

D. Source quality-control reports.

E. Field quality-control reports.

F. Maintenance Data: For wire and cable to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

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

1.6 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
2. Test optical fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.
3. Test each pair of UTP cable for open and short circuits.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install UTP and optical fiber cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. Support of Open Cabling: NRTL labeled for support of Category 5e and Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.

1. Support brackets with cable tie slots for fastening cable ties to brackets.
2. Lacing bars, spools, J-hooks, and D-rings.
3. Straps and other devices.

B. Cable Trays:

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

a. Cable Management Solutions, Inc.
b. Cablofil Inc.
c. Cooper B-Line, Inc.
d. Cope - Tyco/Allied Tube & Conduit.
e. GS Metals Corp.

2. Cable Tray Materials: Metal, suitable for indoors and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inch (0.012 mm) thick hot-dip galvanizing, complying with ASTM A 123/A 123M, Grade 0.55, not less than 0.002165 inch (0.055 mm) thick.

a. Basket Cable Trays: 6 inches (150 mm) wide and 2 inches (50 mm) deep. Wire mesh spacing shall not exceed 2 by 4 inches (50 by 100 mm).
b. Trough or Ventilated Cable Trays: Nominally 6 inches (150 mm) wide.
c. Ladder Cable Trays: Nominally 18 inches (455 mm) wide, and a rung spacing of 12 inches (305 mm).
d. Channel Cable Trays: One-piece construction, nominally 4 inches (100 mm) wide. Slot spacing shall not exceed 4-1/2 inches (115 mm) o.c.
e. Solid-Bottom or Nonventilated Cable Trays: One-piece construction, nominally 12 inches (305 mm) wide. Provide with solid covers.

C. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems." Flexible metal conduit shall not be used.

1. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

2.2 BACKBOARDS

A. Description: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels in Division 06 Section "Rough Carpentry."

2.3 UTP CABLE

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

1. Berk-Tek; a Nexans company.
2. CommScope, Inc.
3. Mohawk; a division of Belden CDT.
4. Superior Essex Inc.

B. Description: 100-ohm, 4-pair UTP, formed into 25-pair, binder groups covered with a blue thermoplastic jacket.

1. Comply with ICEA S-90-661 for mechanical properties.
2. Comply with TIA/EIA-568-B.1 for performance specifications.
3. Comply with TIA/EIA-568-B.2, Category 6.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:

    a. Communications, General Purpose: Type CM or CMG.
    b. Communications, Riser Rated: Type CMR, complying with UL 1666.
    c. Communications, Limited Purpose: Type CMX.

2.4 UTP CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hubbell Premise Wiring.
2. Orthotronics
3. Leviton Voice & Data Division.
4. Panduit Corp.

B. UTP Cable Connecting Hardware: IDC type, using modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of the same category or higher.

C. Connecting Blocks: 110 style for Category 5e and 110 style for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare; integral with connector bodies, including plugs and jacks where indicated.

2.5 OPTICAL FIBER CABLE

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

1. Berk-Tek; a Nexans company.
2. ADC.
3. Corning Cable Systems.
4. American Technology Systems Industries, Inc.
5. Dynacom Corporation.

B. Description: Multimode, 50/125-micrometer, 12-fiber, nonconductive, tight buffer, optical fiber cable.

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA/EIA-568-B.3 for performance specifications.
3. Comply with TIA/EIA-492AAAA-B for detailed specifications.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

   a. General Purpose, Nonconductive: Type OFN or OFNG.
   b. Riser Rated, Nonconductive: Type OFNR, complying with UL 1666.
5. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
6. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

C. Jacket:

1. Jacket Color: Aqua for 50/125-micrometer cable .
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

2.6 OPTICAL FIBER CABLE HARDWARE

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

1. Berk-Tek; a Nexans company.
2. Corning Cable Systems.
3. Dynacom Corporation.
4. CommScope, Inc.
5. Siemon Co. (The).

B. Cable Connecting Hardware: Comply with the Fiber Optic Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.

1. Quick-connect, simplex and duplex, Type SC, Type ST, Type LC, Type MT-RJ connectors. Insertion loss not more than 0.75 dB.
2. Type SFF connectors may be used in termination racks, panels, and equipment packages.

2.7 RS-232 CABLE

A. Standard Cable: NFPA 70, Type CM.

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.

2. Polypropylene insulation.
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
4. PVC jacket.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
6. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. Plastic insulation.
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
4. Plastic jacket.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
6. Flame Resistance: Comply with NFPA 262.

2.8 RS-485 CABLE

A. Standard Cable: NFPA 70, Type CM or Type CMG.

1. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Fluorinated ethylene propylene jacket.
5. Flame Resistance: NFPA 262, Flame Test.

2.9 LOW-VOLTAGE CONTROL CABLE

A. Paired Cable: NFPA 70, Type CMG.

1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

C. Paired Cable: NFPA 70, Type CMG.

1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

D. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Plastic jacket.
5. Flame Resistance: NFPA 262, Flame Test.

2.10 CONTROL-CIRCUIT CONDUCTORS

A. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, Type XHHN, in raceway, complying with UL 83 and/or UL 44.

B. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, in raceway, Type XHHN, in raceway, power-limited cable, concealed in building finishes, power-limited tray cable, in cable tray, complying with UL 83 and/or UL 44.

C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or Type TF, complying with UL 83.

2.11 IDENTIFICATION PRODUCTS

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

1. Brady Corporation.
2. HellermannTyton.
3. Kroy LLC.
4. Panduit Corp.

B. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

C. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

2.12 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.

C. Factory test UTP cables according to TIA/EIA-568-B.2.

D. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.

E. Cable will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF PATHWAYS

A. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.

B. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.

C. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.

D. Install manufactured conduit sweeps and long-radius elbows if possible.

E. Pathway Installation in Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed or in the corner of room if multiple sheets of plywood are installed around perimeter walls of room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard if entering room from overhead.
4. Extend conduits 3 inches (75 mm) above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

F. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.2 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA/EIA-568-B.1.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
6. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
8. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:

1. Comply with TIA/EIA-568-B.2.
2. Install 110-style IDC termination hardware unless otherwise indicated.
3. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.

D. Installation of Control-Circuit Conductors:

1. Install wiring in raceways. Comply with requirements specified in Division 26 Section "Raceway and Boxes for Electrical Systems."

E. Optical Fiber Cable Installation:

1. Comply with TIA/EIA-568-B.3.
2. Cable shall be terminated on connecting hardware that is rack or cabinet mounted.

F. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1525 mm) apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

G. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable 72 inches (1830 mm) long shall be neatly coiled not less than 12 inches (305 mm) in diameter below each feed point.

H. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (305 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (305 mm).

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (75 mm).
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.3 REMOVAL OF CONDUCTORS AND CABLES

A. Remove abandoned conductors and cables.

3.4 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits, No 14 AWG.
2. Class 2 low-energy, remote-control, and signal circuits, No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm, and signal circuits, No 12 AWG.

3.5 FIRESTOPPING

A. Comply with requirements in Division 07 Section "Penetration Firestopping."

B. Comply with TIA/EIA-569-A, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.6 GROUNDING

A. For data communication wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. For low-voltage wiring and cabling, comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems."

3.7 IDENTIFICATION

A. Identify system components, wiring, and cabling according to TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Visually inspect UTP and optical fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA/EIA-568-B.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test UTP cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not after cross connection.

    a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

4. Optical Fiber Cable Tests:

    a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    b. Link End-to-End Attenuation Tests:

        1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
        2) Attenuation test results for links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.

D. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 260523

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes: Grounding systems and equipment.

B. Section includes grounding systems and equipment, plus the following special applications:
   1. Underground distribution grounding.
   2. Foundation steel electrodes.

1.3 SUBMITTALS

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

B. Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:

   1. Test wells.
   2. Ground rods.
   3. Ground rings.
   4. Grounding arrangements and connections for separately derived systems.
   5. Grounding for sensitive electronic equipment.

C. Qualification Data: For qualified testing agency and testing agency's field supervisor.

D. Field quality-control reports.

E. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

   1. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, and grounding connections for separately derived systems based on NETA MTS and NFPA 70B.

      a. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
      b. Include recommended testing intervals.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

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

C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

C. Bare Grounding Conductor and Conductor Protector for Wood Poles:

1. No. 4 AWG minimum, soft-drawn copper.
2. Conductor Protector: Half-round PVC or wood molding; if wood, use pressure-treated fir, cypress, or cedar.

D. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

2.2 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression and exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

E. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

F. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

G. Conduit Hubs: Mechanical type, terminal with threaded hub.

H. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt or socket set screw.

I. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

J. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.

K. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.

L. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.

M. Straps: Solid copper, copper lugs. Rated for 600 A.

N. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal [one] [two]-piece clamp.

O. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

P. Water Pipe Clamps:

1. Mechanical type, two pieces with zinc-plated or stainless-steel bolts.

   a. Material: Die-cast zinc alloy.
   b. Listed for direct burial.

2. U-bolt type with malleable-iron clamp and copper ground connector rated for direct burial.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad, sectional type; 3/4 inch by 10 feet (19 mm by 3 m) and 5/8 by 96 inches (16 by 2400 mm) in diameter.

B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.

1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches (1200 mm) long.
2. Backfill Material: Electrode manufacturer's recommended material.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.

1. Bury at least 24 inches (600 mm) below grade.
2. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor 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.

D. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down to specified height above floor; connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

3.4 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.
8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.

C. 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.

D. 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.

E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

F. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.

1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-12-inch (6.3-by-100-by-300-mm) grounding bus.
3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

G. Metal and Wood Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.5 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

C. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 26 Section "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches (300 mm) deep, with cover.

1. Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

D. 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 connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

E. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

G. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.

H. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column and/or indicated item, extending around the perimeter of building, area, and/or item indicated.

1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
2. Bury ground ring not less than 24 inches (600 mm) from building's foundation.

I. 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.

J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 feet (6.0 m) long. If reinforcing is in multiple pieces, connect together by the usual steel tie wires or exothermic welding to create the required length.

3.6 LABELING

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems" Article for instruction signs. The label or its text shall be green.

B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.

1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.

a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural

drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.

b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

E. Grounding system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
5. Substations and Pad-Mounted Equipment: 5 ohms.
6. Manhole Grounds: 10 ohms.

H. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

B. Related Sections include the following:

1. Division 26 Section "Vibration and Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

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

D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five (5) times the applied force.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Steel slotted support systems.
2. Nonmetallic slotted support systems.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1. Trapeze hangers. Include Product Data for components.
2. Steel slotted channel systems. Include Product Data for components.
3. Nonmetallic slotted channel systems. Include Product Data for components.
4. Equipment supports.

C. Welding certificates.

1.6 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

1.7 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.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA 4, factory-fabricated components for field assembly.

1. 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:

a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.; a division of Cooper Industries.
c. ERICO International Corporation.
d. GS Metals Corp.
e. Thomas & Betts Corporation.
f. Unistrut; Tyco International, Ltd.
g. Wesanco, Inc.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.

4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
5. Channel Dimensions: Selected for applicable load criteria.

B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch-diameter holes at a maximum of 8 inches o.c., in at least one (1) surface.

1. 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:

    a. Allied Tube & Conduit.
    b. Cooper B-Line, Inc.; a division of Cooper Industries.
    c. Fabco Plastics Wholesale Limited.
    d. Seasafe, Inc.

2. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
3. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
4. Rated Strength: Selected to suit applicable load criteria.

C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

D. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36, steel plates, shapes, and bars; black and galvanized.

G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

    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) Hilti Inc.
        2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
        3) MKT Fastening, LLC.
        4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated and stainless steel, for use in hardened Portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1) Cooper B-Line, Inc.; a division of Cooper Industries.
2) Empire Tool and Manufacturing Co., Inc.
3) Hilti Inc.
4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by scheduled in NECA 1, where its Table 1 lists maximum spacings less than stated in NFPA 70. Minimum rod size shall be ¼ inch in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least twenty-five percent (25%) in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps single-bolt conduit clamps single-bolt conduit clamps using spring friction action for retention in support channel.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1½-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Steel: Welded threaded studs complying with AWS D1.1, with lock washers and nuts, Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69, Spring-tension clamps.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, twenty-eight (28) day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

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

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

B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

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

END OF SECTION 260529

SECTION 260533 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

B. Related Sections include the following:

1. Division 26 Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. ENT: Electrical nonmetallic tubing.

C. EPDM: Ethylene-propylene-diene terpolymer rubber.

D. FMC: Flexible metal conduit.

E. IMC: Intermediate metal conduit.

F. LFMC: Liquidtight flexible metal conduit.

G. LFNC: Liquidtight flexible nonmetallic conduit.

H. NBR: Acrylonitrile-butadiene rubber.

I. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.

1. Custom enclosures and cabinets.
2. For handholes and boxes for underground wiring, including the following:

a. Duct entry provisions, including locations and duct sizes.
b. Frame and cover design.
c. Grounding details.
d. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
e. Joint details.

C. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members in the paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.

D. Manufacturer Seismic Qualification Certification: Submit certification that enclosures and cabinets and their mounting provisions, including those for internal components, will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

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

a. The term "withstand" means "the cabinet or enclosure will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will retain its enclosure characteristics, including its interior accessibility, after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Qualification Data: For professional engineer and testing agency.

F. Source quality-control test reports.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. AFC Cable Systems, Inc.
2. Alflex Inc.
3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. Anamet Electrical, Inc.; Anaconda Metal Hose.
5. Electri-Flex Co.
6. Manhattan/CDT/Cole-Flex.
7. Maverick Tube Corporation.
8. O-Z Gedney; a unit of General Signal.
9. Wheatland Tube Company.

C. Rigid Steel Conduit: ANSI C80.1.

D. Aluminum Rigid Conduit: ANSI C80.5.

E. IMC: ANSI C80.6.

F. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit and IMC.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch (1 mm), minimum.

G. EMT: ANSI C80.3.

H. FMC: Zinc-coated steel or aluminum.

I. LFMC: Flexible steel conduit with PVC jacket.

J. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
2. Fittings for EMT: Steel or die-cast and set-screw or compression type.
3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

K. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.; Anaconda Metal Hose.
3. Arnco Corporation.
4. CANTEX Inc.
5. CertainTeed Corp.; Pipe & Plastics Group.
6. Condux International, Inc.

7. ElecSYS, Inc.
8. Electri-Flex Co.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT/Cole-Flex.
11. RACO; a Hubbell Company.
12. Thomas & Betts Corporation.

C. ENT: NEMA TC 13.

D. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

E. LFNC: UL 1660.

F. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.

G. Fittings for LFNC: UL 514B.

2.3 METAL WIREWAYS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.

C. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 3R, unless otherwise indicated.

D. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

E. Wireway Covers: Hinged type, Screw-cover type, Flanged-and-gasketed type, or as indicated.

F. Finish: Manufacturer's standard enamel finish.

2.4 NONMETALLIC WIREWAYS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Hoffman.
2. Lamson & Sessions; Carlon Electrical Products.

C. Description: Fiberglass polyester, extruded and fabricated to size and shape indicated, with no holes or knockouts. Cover is gasketed with oil-resistant gasket material and fastened with

captive screws treated for corrosion resistance. Connections are flanged, with stainless-steel screws and oil-resistant gaskets.

D. Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.

E. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.5 SURFACE RACEWAYS

A. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect.

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Thomas & Betts Corporation.
    b. Walker Systems, Inc.; Wiremold Company (The).
    c. Wiremold Company (The); Electrical Sales Division.

B. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard or custom colors.

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Butler Manufacturing Company; Walker Division.
    b. Enduro Systems, Inc.; Composite Products Division.
    c. Hubbell Incorporated; Wiring Device-Kellems Division.
    d. Lamson & Sessions; Carlon Electrical Products.
    e. Panduit Corp.
    f. Walker Systems, Inc.; Wiremold Company (The).
    g. Wiremold Company (The); Electrical Sales Division.

2.6 BOXES, ENCLOSURES, AND CABINETS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
2. EGS/Appleton Electric.
3. Erickson Electrical Equipment Company.

4. Hoffman.
5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
6. O-Z/Gedney; a unit of General Signal.
7. RACO; a Hubbell Company.
8. Robroy Industries, Inc.; Enclosure Division.
9. Scott Fetzer Co.; Adalet Division.
10. Spring City Electrical Manufacturing Company.
11. Thomas & Betts Corporation.
12. Walker Systems, Inc.; Wiremold Company (The).
13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.

C. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

D. Cast-Metal Outlet and Device Boxes: NEMA FB 1, cast feralloy, Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: NEMA OS 2.

F. Metal Floor Boxes: Cast iron or sheet metal, fully adjustable, rectangular.

G. Nonmetallic Floor Boxes: Nonadjustable, round.

H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

I. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized cast iron with gasketed cover.

J. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures: Plastic, finished inside with radio-frequency-resistant paint.

K. Cabinets:

1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

2.7 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Description: Comply with SCTE 77.

1. Color of Frame and Cover: Gray.
2. Configuration: Units shall be designed for flush burial and have integral closed bottom, unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, "ELECTRIC." And "TELEPHONE.", or as indicated for each service.

6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
7. Handholes 2 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or a combination of the two.

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

    a. Armorcast Products Company.
    b. Carson Industries LLC.
    c. CDR Systems Corporation.
    d. NewBasis.

C. Fiberglass Handholes and Boxes with Polymer-Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester-resin enclosure joined to polymer-concrete top ring or frame.

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

    a. Armorcast Products Company.
    b. Carson Industries LLC.
    c. Christy Concrete Products.
    d. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.

D. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete.

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

    a. Carson Industries LLC.
    b. Christy Concrete Products.
    c. Nordic Fiberglass, Inc.

2.8 SLEEVES FOR RACEWAYS

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch (1.3- or 3.5-mm) thickness as indicated and of length to suit application.

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.9 SLEEVE SEALS

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:

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

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Advance Products & Systems, Inc.
2. Calpico, Inc.
3. Metraflex Co.
4. Pipeline Seal and Insulator, Inc.

D. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.

1. Sealing Elements: EPDM 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 pressure plates to sealing elements. Include one for each sealing element.

2.10 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by a independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed Conduit: Rigid steel conduit, IMC, RNC, Type EPC-40-PVC, RNC, Type EPC-80-PVC.
2. Concealed Conduit, Aboveground: Rigid steel conduit, IMC, RNC, Type EPC-40-PVC, RNC, Type EPC-80-PVC.
3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC and/or LFNC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.
6. Application of Handholes and Boxes for Underground Wiring:

    a. Handholes and Pull Boxes in Driveway, Parking Lot, and Off-RoadwayLocations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete and Fiberglass enclosures with polymer-concrete frame and cover, SCTE 77, Tier 15 structural load rating.
    b. Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Heavy-duty fiberglass units with polymer-concrete frame and cover, SCTE 77, Tier 8 structural load rating.
    c. Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.

B. Comply with the following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT, ENT, or RNC.Exposed, Not Subject to Severe Physical Damage: EMT, RNC identified for such use.
2. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:

    a. Loading dock.
    b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    c. Mechanical rooms.

3. Concealed in Ceilings and Interior Walls and Partitions: EMT, ENT, or RNC, Type EPC-40-PVC.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
5. Damp or Wet Locations: Rigid steel conduit.
6. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical fiber/communications cable raceway, EMT.
7. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: Riser-type, optical fiber/communications cable raceway, EMT.
8. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: General-use, optical fiber/communications cable raceway , Riser-type, optical fiber/communications cable raceway, Plenum-type, optical fiber/communications cable raceway, EMT.
9. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel nonmetallic in damp or wet locations.

C. Minimum Raceway Size: 3/4-inch (21-mm) trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits in contact with concrete.

3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

H. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Change from ENT to RNC, Type EPC-40-PVC, rigid steel conduit, or IMC before rising above the floor.

I. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

K. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire.

L. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:

1. 3/4-Inch (19-mm) Trade Size and Smaller: Install raceways in maximum lengths of 50 feet (15 m).
2. 1-Inch (25-mm) Trade Size and Larger: Install raceways in maximum lengths of 75 feet (23 m).
3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

M. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where otherwise required by NFPA 70.

N. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m).

1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
    c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
    d. Attics: 135 deg F (75 deg C) temperature change.

2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change.
3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

O. Flexible Conduit Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

P. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

Q. Set metal floor boxes level and flush with finished floor surface.

R. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.
2. Install backfill as specified in Division 31 Section "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
    b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

6. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried conduits, placing them 24 inches (600 mm) o.c. Align planks along the width and along the centerline of conduit.

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.

D. Install handholes and boxes with bottom below the frost line, below grade.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.

F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Rectangular Sleeve Minimum Metal Thickness:

1. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side greater than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
2. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches (1270 mm) and 1 or more sides equal to, or greater than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

E. 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.

F. Cut sleeves to length for mounting flush with both surfaces of walls.

G. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.

H. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway unless sleeve seal is to be installed or unless seismic criteria require different clearance.

I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

J. 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. Refer to Division 07 Section "Joint Sealants" for materials and installation.

K. 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 Division 07 Section "Penetration Firestopping."

L. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.

M. Aboveground, 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.

N. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway and sleeve for installing mechanical sleeve seals.

3.6 SLEEVE-SEAL INSTALLATION

A. Install to seal underground, 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.

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.8 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

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. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Sealing Elements: EPDM or Nitrile (Buna N)] rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel, Plastic or Stainless steel].
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, stainless steel of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

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

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide [1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel or cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 260544

SECTION 260548 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Isolation pads.
2. Spring isolators.
3. Restrained spring isolators.
4. Channel support systems.
5. Restraint cables.
6. Hanger rod stiffeners.
7. Anchorage bushings and washers.

B. Related Sections include the following:

1. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 DEFINITIONS

A. The IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: E.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: III.

a. Component Importance Factor: 1.5.
b. Component Response Modification Factor: 5.5.
c. Component Amplification Factor: 1.0.

3. Design Spectral Response Acceleration at Short Periods (0.2 Second).

1.5 ACTION SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

    a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
    b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.

    a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other electrical Sections for equipment mounted outdoors.

2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
3. Field-fabricated supports.
4. Seismic-Restraint Details:

    a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
    b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
    c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Field quality-control test reports.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

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

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
3. California Dynamics Corporation.
4. Isolation Technology, Inc.
5. Kinetics Noise Control.
6. Mason Industries.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
9. Vibration Mountings & Controls, Inc.

B. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant neoprene.

C. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.

3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

D. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.2 SEISMIC-RESTRAINT DEVICES

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

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Hilti Inc.
5. Loos & Co.; Seismic Earthquake Division.
6. Mason Industries.
7. TOLCO Incorporated; a brand of NIBCO INC.
8. Unistrut; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

D. Restraint Cables: ASTM A 603 galvanized-steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Do not weld stiffeners to rods.

F. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.

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

H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

I. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

J. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.3 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment and Hanger Restraints:

1. Install restrained isolators on electrical equipment.
2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

D. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after isolated equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 260548

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.

1.3 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

1.4 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

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.

1.5 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 29 CFR 1910.145. Use consistent designations throughout Project.

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

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

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

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

B. Colors for Raceways Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

C. Colors for Raceways Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.
2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high letters on 20-inch (500-mm) centers.

D. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

E. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

F. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

G. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers diagonally over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stop stripes at legends.

H. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.

I. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Colors for Raceways Carrying Circuits at 600 V and Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

C. Colors for Raceways Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.
2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high letters on 20-inch (500-mm) centers.

D. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

E. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches (50 mm) wide; compounded for outdoor use.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.

D. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

E. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

F. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

D. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

E. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

F. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.5 FLOOR MARKING TAPE

A. 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

B. Furnish and install tape at location in accordance with NEC 110.26 for all electrical distribution equipment.

2.6 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

C. Tag: Type I:

1. Pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Thickness: 4 mils (0.1 mm).
3. Weight: 18.5 lb/1000 sq. ft. (9.0 kg/100 sq. m).
4. 3-Inch (75-mm) Tensile According to ASTM D 882: 30 lbf (133.4 N), and 2500 psi (17.2 MPa).

D. Tag: Type II:

1. Multilayer laminate consisting of high-density polyethylene scrim coated with pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Thickness: 12 mils (0.3 mm).
3. Weight: 36.1 lb/1000 sq. ft. (17.6 kg/100 sq. m).
4. 3-Inch (75-mm) Tensile According to ASTM D 882: 400 lbf (1780 N), and 11,500 psi (79.2 MPa).

E. Tag: Type ID:

1. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Overall Thickness: 5 mils (0.125 mm).
3. Foil Core Thickness: 0.35 mil (0.00889 mm).
4. Weight: 28 lb/1000 sq. ft. (13.7 kg/100 sq. m).
5. 3-Inch (75-mm) Tensile According to ASTM D 882: 70 lbf (311.3 N), and 4600 psi (31.7 MPa).

F. Tag: Type IID:

1. Reinforced, detectable three-layer laminate, consisting of a printed pigmented woven scrim, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Overall Thickness: 8 mils (0.2 mm).
3. Foil Core Thickness: 0.35 mil (0.00889 mm).
4. Weight: 34 lb/1000 sq. ft. (16.6 kg/100 sq. m).
5. 3-Inch (75-mm) Tensile According to ASTM D 882: 300 lbf (1334 N), and 12,500 psi (86.1 MPa).

2.7 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. 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 indicated.

C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 7 by 10 inches (180 by 250 mm).

D. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 10 by 14 inches (250 by 360 mm).

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

2.8 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. inches (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.

2.9 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).

B. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.

C. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).

D. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).

E. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch (25 mm).

2.10 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black.

C. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 7000 psi (48.2 MPa).
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
5. Color: Black.

2.11 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

2.12 POWER RECEPTACLES

A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).

B. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.

C. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm)

2.13 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, 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 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.

G. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

H. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

I. 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.

J. Painted Identification: Comply with requirements in Division 09 painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

A. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high black letters on 20-inch (500-mm) centers. Stop stripes at legends. Apply to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within 12 inches (300 mm) of a floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to raceways concealed within wall.
3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

B. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Self-adhesive vinyl labels. Install labels at 30-foot (10-m) maximum intervals.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Identify with self-adhesive vinyl label. Install labels at 30-foot (10-m) maximum intervals.

D. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:

1. Power.

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.

   a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
   b. Colors for 208/120-V Circuits:

      1) Phase A: Black.
      2) Phase B: Red.
      3) Phase C: Blue.

   c. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

F. Power-Circuit Conductor Identification, More than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use write-on tags, nonmetallic plastic tag holder with adhesive-backed phase tags, and a separate tag with the circuit designation.

G. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

H. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.

I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

J. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.

1. Limit use of underground-line warning tape to direct-buried cables.
2. Install underground-line warning tape for both direct-buried cables and cables in raceway.

K. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

L. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.

1. Comply with 29 CFR 1910.145.
2. Identify system voltage with black letters on an orange background.
3. Apply to exterior of door, cover, or other access.
4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:

    a. Power transfer switches.
    b. Controls with external control power connections.

M. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

N. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

a. Indoor Equipment: Adhesive film label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
b. Outdoor Equipment: Engraved, laminated acrylic or melamine label [Stenciled legend 4 inches (100 mm) high.
c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment to Be Labeled:

a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive and engraved laminated acrylic or melamine label.
b. Enclosures and electrical cabinets.
c. Access doors and panels for concealed electrical items.
d. Switchgear.
e. Switchboards.
f. Substations.
g. Enclosed switches.
h. Enclosed circuit breakers.
i. Enclosed controllers.
j. Variable-speed controllers.
k. Push-button stations.
l. Contactors.
m. Remote-controlled switches, dimmer modules, and control devices.
n. Battery racks.
o. Power-generating units.
p. Monitoring and control equipment.

END OF SECTION 260553

SECTION 260572 - SHORT-CIRCUIT STUDIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.3 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed and salvaged, or removed and reinstalled. Existing to remain items shall remain functional throughout the construction period.

B. Field Adjusting Agency: An independent electrical testing agency with full-time employees and the capability to adjust devices and conduct testing indicated and that is a member company of NETA.

C. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

D. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.

E. Power Systems Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.

F. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion of the circuit from the system.

G. SCCR: Short-circuit current rating.

H. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

I. Single-Line Diagram: See "One-Line Diagram."

1.4 ACTION SUBMITTALS

A. Product Data:

1. For computer software program to be used for studies.

2. Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.

    a. Short-circuit study input data, including completed computer program input data sheets.
    b. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.

        1) Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
        2) Revised one-line diagram, reflecting field investigation results and results of short-circuit study.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. For Power Systems Analysis Software Developer.
2. For Power System Analysis Specialist.
3. For Field Adjusting Agency.

B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. For overcurrent protective devices to include in emergency, operation, and maintenance manuals.
2. The following are from the Short-Circuit Study Report:

    a. Final one-line diagram.
    b. Final Short-Circuit Study Report.
    c. Short-circuit study data files.
    d. Power system data.

1.7 QUALITY ASSURANCE

A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Software algorithms shall comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.

1. Power System Analysis Software Qualifications: Computer program shall be designed to perform short-circuit studies or have a function, component, or add-on module designed to perform short-circuit studies.

2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

D. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

E. Short-Circuit Study Certification: Short-Circuit Study Report shall be signed and sealed by Power Systems Analysis Specialist.

F. Field Adjusting Agency Qualifications:

1. Employer of a NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification responsible for all field adjusting of the Work.
2. A member company of NETA.
3. Acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

A. Comply with IEEE 399 and IEEE 551.

1. Analytical features of power systems analysis software program shall have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

B. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram of modeled power system, showing the following:

1. Protective device designations and ampere ratings.
2. Conductor types, sizes, and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
6. Derating factors and environmental conditions.
7. Any revisions to electrical equipment required by the study.

D. Comments and recommendations for system improvements or revisions in a written document, separate from one-line diagram.

E. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.
2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

F. Short-Circuit Study Input Data:

1. One-line diagram of system being studied.
2. Power sources available.
3. Manufacturer, model, and interrupting rating of protective devices.
4. Conductors.
5. Transformer data.

G. Short-Circuit Study Output Reports:

1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

    a. Voltage.
    b. Calculated fault-current magnitude and angle.
    c. Fault-point X/R ratio.
    d. Equivalent impedance.

2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

    a. Voltage.
    b. Calculated symmetrical fault-current magnitude and angle.
    c. Fault-point X/R ratio.
    d. Calculated asymmetrical fault currents:

        1) Based on fault-point X/R ratio.
        2) Based on calculated symmetrical value multiplied by 1.6.
        3) Based on calculated symmetrical value multiplied by 2.7.

3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

    a. Voltage.
    b. Calculated symmetrical fault-current magnitude and angle.
    c. Fault-point X/R ratio.
    d. No AC Decrement (NACD) ratio.
    e. Equivalent impedance.
    f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
    g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

PART 3 - EXECUTION

3.1 POWER SYSTEM DATA

A. Obtain all data necessary for conduct of the study.

1. Verify completeness of data supplied on one-line diagram. Call any discrepancies to Architect's attention.
2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.

B. Gather and tabulate the required input data to support the short-circuit study. Comply with requirements in Section 017839 "Project Record Documents" for recording circuit protective device characteristics. Record data on a Record Document copy of one-line diagram. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification. Data include, but are not limited to, the following:

1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
7. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
8. Motor horsepower and NEMA MG 1 code letter designation.
9. Conductor sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
10. Derating factors.

3.2 SHORT-CIRCUIT STUDY

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on device characteristics supplied by device manufacturer.

D. Extent of electrical power system to be studied is indicated on Drawings.

E. Begin short-circuit current analysis at the service, extending down to system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.

2. Exclude equipment rated 240 V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for the fault-current dc decrement to address asymmetrical requirements of interrupting equipment.

H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

I. Include in the report identification of any protective device applied outside its capacity.

END OF SECTION 260573.13

SECTION 260573 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes computer-based, fault-current and overcurrent protective device coordination studies. Protective devices shall be set based on results of the protective device coordination study.

1. Coordination of series-rated devices is permitted where indicated on Drawings.

1.3 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: The following submittals shall be made after the approval process for system protective devices has been completed. Submittals may be in digital form.

1. Coordination-study input data, including completed computer program input data sheets.
2. Study and Equipment Evaluation Reports.
3. Coordination-Study Report.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For coordination-study specialist.

B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.

1.5 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Coordination-Study Specialist Qualifications: 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. Professional engineer, licensed in the state where Project is located, shall be responsible for the study. All elements of the study shall be performed under the direct supervision and control of engineer.

C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

D. Comply with IEEE 399 for general study procedures.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide [the product indicated on Drawings] or a comparable product by one of the following:

1. CGI CYME.
2. EDSA Micro Corporation.
3. ESA Inc.
4. Operation Technology, Inc.
5. SKM Systems Analysis, Inc.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

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.

1. Optional Features:

a. Arcing faults.
b. Simultaneous faults.
c. Explicit negative sequence.
d. Mutual coupling in zero sequence.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 POWER SYSTEM DATA

A. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other electrical Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Impedance of utility service entrance.
3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:

    a. Circuit-breaker and fuse-current ratings and types.
    b. Relays and associated power and current transformer ratings and ratios.
    c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
    d. Generator kilovolt amperes, size, voltage, and source impedance.
    e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.
    f. Busway ampacity and impedance.
    g. Motor horsepower and code letter designation according to NEMA MG 1.

4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:

    a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
    c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    d. Generator thermal-damage curve.
    e. Ratings, types, and settings of utility company's overcurrent protective devices.
    f. Special overcurrent protective device settings or types stipulated by utility company.
    g. Time-current-characteristic curves of devices indicated to be coordinated.
    h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
    i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
    j. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

3.3 FAULT-CURRENT STUDY

A. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit-breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:

1. Switchgear and switchboard bus.

2. Medium-voltage controller.
3. Motor-control center.
4. Distribution panelboard.
5. Branch circuit panelboard.

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 141, IEEE 241 and IEEE 242.

1. Transformers:

a. ANSI C57.12.10.
b. ANSI C57.12.22.
c. ANSI C57.12.40.
d. IEEE C57.12.00.
e. IEEE C57.96.

2. Medium-Voltage Circuit Breakers: IEEE C37.010.
3. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1.
4. Low-Voltage Fuses: IEEE C37.46.

E. Study Report:

1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.
2. Show interrupting (5-cycle) and time-delayed currents (6 cycles and above) on medium-voltage breakers as needed to set relays and assess the sensitivity of overcurrent relays.

F. Equipment Evaluation Report:

1. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
3. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

3.4 COORDINATION STUDY

A. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.

1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.
2. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short-circuit currents.
3. Calculate the maximum and minimum ground-fault currents.

B. Comply with IEEE 141, IEEE 241 and IEEE 242 recommendations for fault currents and time intervals.

1. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

C. Motors served by voltages more than 600 V shall be protected according to IEEE 620.

D. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

E. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:

1. Tabular Format of Settings Selected for Overcurrent Protective Devices:

a. Device tag.
b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
d. Fuse-current rating and type.
e. Ground-fault relay-pickup and time-delay settings.

2. 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, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

a. Device tag.
b. Voltage and current ratio for curves.
c. Three-phase and single-phase damage points for each transformer.
d. No damage, melting, and clearing curves for fuses.
e. Cable damage curves.
f. Transformer inrush points.
g. Maximum fault-current cutoff point.

F. Completed data sheets for setting of overcurrent protective devices.

END OF SECTION 260573

SECTION 260574 - OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.3 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Study Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Arc-flash study input data, including completed computer program input data sheets.
2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.

    a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Arc-Flash Study Software Developer Retain "Product Certificates" Paragraph below to require submittal of product certificates from manufacturers.

B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.
2. Operation and Maintenance Procedures: In addition to items specified in Section 017823 "Operation and Maintenance Data," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.7 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Comply with IEEE 1584 and NFPA 70E.

B. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.2 ARC-FLASH STUDY REPORT CONTENT

A. Executive summary.

B. Study descriptions, purpose, basis and scope.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output: As specified in "Short Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."

F. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 260573 "Overcurrent Protective Device Coordination Study."

G. Arc-Flash Study Output:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. No AC Decrement (NACD) ratio.
e. Equivalent impedance.
f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

H. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.
2. Protective 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.

I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

2.3 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

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.

C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Preparatory Studies:

1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."
2. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 260573 "Overcurrent Protective Device Coordination Study."

C. Calculate maximum and minimum contributions of fault-current size.

1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.

E. Include medium- and low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.

F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.

G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond three to five cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:

1. When the circuit breaker is in a separate enclosure.
2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.3 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.

1. Verify completeness of data supplied on the one-line diagram on Drawings[and under "Preparatory Studies" Paragraph in "Arc-Flash Hazard Analysis" Article]. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers.

B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.

4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in per cent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
13. Motor horsepower and NEMA MG 1 code letter designation.
14. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
15. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.

3.4 LABELING

A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:

1. Motor-control center.
2. Low-voltage switchboard.
3. Switchgear.
4. Medium-voltage switch.
5. Control panel.

3.5 APPLICATION OF WARNING LABELS

A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

3.6 DEMONSTRATION

A. Engage the Arc-Flash Study Specialist to train Owner's maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

END OF SECTION 260574

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following lighting control devices:

1. Time switches.
2. Outdoor and indoor photoelectric switches.
3. Indoor occupancy and vacancy sensors.
4. Digital timer light switch
5. Lighting contactors.
6. Emergency shunt relay

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. PIR: Passive infrared.

1.4 SUBMITTALS

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

B. Shop Drawings: Show installation details for occupancy and light-level sensors.

1. Interconnection diagrams showing field-installed wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

a. Refer to specifications 017823 Operation and Maintenance Data for additional O&M requirements

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 TIME SWITCHES

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Area Lighting Research, Inc.; Tyco Electronics.
2. Grasslin Controls Corporation; a GE Industrial Systems Company.
3. Intermatic, Inc.
4. Leviton Mfg. Company Inc.
5. Lightolier Controls; a Genlyte Company.
6. Lithonia Lighting; Acuity Lighting Group, Inc.
7. Paragon Electric Co.; Invensys Climate Controls.
8. Square D; Schneider Electric.
9. TORK.
10. Touch-Plate, Inc.
11. Watt Stopper (The).

B. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.

1. Contact Configuration: SPST, DPST, and DPDT.
2. Contact Rating: 30-A inductive or resistive, 240-V ac, and 20-A ballast load, 120/240-V ac.
3. Program: 8 on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays.
4. Program: 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.
5. Programs: channels; each channel shall be individually programmable with 8 on-off set points on a 24-hour schedule.
6. Programs: channels; each channel shall be individually programmable with 2 on-off set points on a 24-hour schedule with skip-a-day weekly schedule.
7. Programs: channels; each channel shall be individually programmable with 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week.
8. Programs: channels; each channel shall be individually programmable with 40 on-off operations per week and an annual holiday schedule that overrides the weekly operation on holidays.
9. Programs: channels; each channel shall be individually programmable with 40 on-off operations per week, plus 4 seasonal schedules that modify the basic program, and an annual holiday schedule that overrides the weekly operation on holidays.
10. Program: an annual holiday schedule that overrides the weekly operation on holidays.
11. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
12. Astronomic Time: All channels.
13. Battery Backup: For schedules and time clock.

C. Electromechanical-Dial Time Switches: Type complying with UL 917.

1. Contact Configuration: SPST, DPST, SPDT, and DPDT.
2. Contact Rating: 30-A inductive or resistive, 240-V ac, 20-A ballast load, 120/240-V ac.
3. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
4. Astronomic time dial.
5. Eight-Day Program: Uniquely programmable for each weekday and holidays.
6. Skip-a-day mode.
7. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings:

1. Area Lighting Research, Inc.; Tyco Electronics.
2. Grasslin Controls Corporation; a GE Industrial Systems Company.
3. Intermatic, Inc.
4. Lithonia Lighting; Acuity Lighting Group, Inc.
5. Novitas, Inc.
6. Paragon Electric Co.; Invensys Climate Controls.
7. Square D; Schneider Electric.
8. TORK.
9. Touch-Plate, Inc.
10. Watt Stopper (The).

B. Description: Solid state, with SPST and DPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.

1. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
2. Time Delay: 15-second minimum, to prevent false operation.
3. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

C. Description: Solid state, with SPST and DPST dry contacts rated for 1800 VA to operate connected load, relay, or contactor coils; complying with UL 773.

1. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range.
2. Time Delay: 30-second minimum, to prevent false operation.
3. Lightning Arrester: Air-gap type.
4. Mounting: Twist lock complying with IEEE C136.10, with base.

2.3 INDOOR OCCUPANCY SENSORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings:

1. Hubbell Lighting.
2. Leviton Mfg. Company Inc.
3. Lithonia Lighting; Acuity Lighting Group, Inc.
4. Novitas, Inc.
5. RAB Lighting, Inc.
6. Sensor Switch, Inc.
7. TORK.
8. Watt Stopper (The).

B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
4. Mounting:

    a. Sensor: Suitable for mounting in any position on a standard outlet box.
    b. Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
    c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
6. Bypass Switch: Override the on function in case of sensor failure.
7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lx); keep lighting off when selected lighting level is present.

C. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.

1. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
3. Detection Coverage (Corridor): Detect occupancy within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling.

D. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.

1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).

2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. (56 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. (186 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling in a corridor not wider than 14 feet (4.3 m).

E. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
4. operation of the sensor.

2.4 INDOOR OCCUPANCY AND VACANCY SENSORS

A. General Requirements for Sensors:

1. Wall or Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
2. Dual technology.
3. Separate power pack.
4. Hardwired connection to switch BAS; and BAS and lighting control system.
5. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
6. Operation:

    a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
    b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
    c. Combination Sensor: Unless otherwise indicated, sensor must be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

7. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A
8. Power: Line voltage.
9. Power Pack: Dry contacts rated for 20 A LED load at 120 V(ac), and for 1 hp at 120 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.
10. Mounting:

a. Sensor: Suitable for mounting in any position in a standard device box or outlet box.
b. Relay: Externally mounted through a 1/2 inch knockout in a standard electrical enclosure.
c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
12. Bypass Switch: Override the "on" function in case of sensor failure.
13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.

B. PIR Type: Wall or Ceiling mounted; detect occupants in coverage area by their heat and movement.

1. Detector Sensitivity: Detect occurrences of 6 inch minimum movement of any portion of a human body that presents a target of not less than 36 sq. inch.
2. Detection Coverage (Room, Ceiling Mounted): Detect occupancy anywhere in a circular area of 1000 sq. ft. when mounted on a 96 inch high ceiling.
3. Detection Coverage (Corridor, Ceiling Mounted): Detect occupancy within 90 ft.when mounted on a 10 ft. high ceiling.
4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 3000 sq. ft. when mounted 48 inch above finished floor.

C. Ultrasonic Type: [Wall] [Ceiling] mounted; detect occupants in coverage area through pattern changes of reflected ultrasonic energy.

1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inch in either a horizontal or a vertical manner at an approximate speed of 12 inch/s.
2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. when mounted on a 96 inch high ceiling.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96 inch high ceiling.
4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. when mounted on a 96 inch high ceiling.
5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 ft. when mounted on a 10 ft.high ceiling in a corridor not wider than 14 ft..
6. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 3000 sq. ft. when mounted 84 inch above finished floor.

D. Dual-Technology Type: [Wall] [Ceiling] mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6 inch minimum movement of any portion of a human body that presents a target of not less than 36 sq. inch, and detect a person of average size and weight moving not less than 12 inch in either a horizontal or a vertical manner at an approximate speed of 12 inch/s.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft.when mounted on a 96 inch high ceiling.

4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of [3000 sq. ft.] when mounted 48 inch above finished floor.

2.5 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox, with provisions for connection to BAS, and using hardwired connection.

1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time, delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
4. Switch Rating: Not less than 800 VA LED load at 120 V.

B. Wall-Switch Sensor:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 2100 sq. ft.
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Switch Type: SP, field-selectable automatic "on," or manual "on," automatic "off."
4. Capable of controlling load in three-way application.
5. Voltage: Match the circuit voltage 120 V Dual voltage – 120V.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
8. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
10. Color: White.
11. Faceplate: Color matched to switch.

C. Wall-Switch Sensor:

1. Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq. ft.
2. Sensing Technology: PIR.
3. Switch Type: SP, field-selectable automatic "on," or manual "on," automatic "off."
4. Capable of controlling load in three-way application.
5. Voltage: Match the circuit voltage 120 V, Dual voltage, 120 and 277 V.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
8. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
10. Color: White.
11. Faceplate: Color matched to switch.

2.6 LIGHTING CONTACTORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Allen-Bradley/Rockwell Automation.
2. ASCO Power Technologies, LP; a division of Emerson Electric Co.
3. Eaton Electrical Inc.; Cutler-Hammer Products.
4. GE Industrial Systems; Total Lighting Control.
5. Grasslin Controls Corporation; a GE Industrial Systems Company.
6. Hubbell Lighting.
7. Lithonia Lighting; Acuity Lighting Group, Inc.
8. MicroLite Lighting Control Systems.
9. Square D; Schneider Electric.
10. TORK.
11. Touch-Plate, Inc.
12. Watt Stopper (The).

B. Description: Electrically operated and electrically held, combination type with nonfused disconnect, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.
4. Provide with control and pilot devices as indicated on Drawings and schedule, matching the NEMA type specified for the enclosure.

C. BAS Interface: Provide hardware interface to enable the BAS to monitor and control lighting contactors.

1. Monitoring: On-off status.
2. Control: On-off operation.

2.7 EMERGENCY SHUNT RELAY

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
1. LVS, Inc.
2. Sensor Switch
3. Watt Stopper

B. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts (dual-contact where required); complying with UL 924.

1. Coil Rating: 120-277 V or as indicated on drawings.

2.8 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 CONTACTOR INSTALLATION

A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch (13 mm).

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
2. Operational Test: Verify operation of each lighting control device, and adjust time delays.

B. Lighting control devices that fail tests and inspections are defective work.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 260923

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

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

1.4 SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Include evidence of NRTL listing for series rating of installed devices.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include wiring diagrams for power, signal, and control wiring.
8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

C. Qualification Data: For qualified testing agency.

D. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

G. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. 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.

E. Comply with NEMA PB 1.

F. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NECA 407 and NEMA PB 1.

1.7 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding minus 22 deg F (minus 30 deg C) 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).
b. Altitude: Not exceeding 6600 feet (2000 m).

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet (2000 m).

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Architect and Construction Manager Owner no fewer than two days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Architect's and Construction Manager's written permission.
3. Comply with NFPA 70E.

1.8 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

1.10 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. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.
3. 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.
4. Fuses for Fused Power-Circuit Devices: 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

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

B. Enclosures: Flush- and surface-mounted cabinets.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250
b. Outdoor Locations: NEMA 250, Type 3R.
c. Kitchen and Wash-Down Areas: NEMA 250, Type 4X.
d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 5 or Type 12.

2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
6. Finishes:

a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
b. Back Boxes: Same finish as panels and trim.
c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

7. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.

C. Incoming Mains Location: Top and bottom.

D. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
3. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
4. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
5. Split Bus: Vertical buses divided into individual vertical sections.

E. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Main and Neutral Lugs: Compression type.
3. Ground Lugs and Bus-Configured Terminators: Compression type.
4. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
5. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
6. Gutter-Tap Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
7. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.

G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

H. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include size and type of allowable upstream and branch devices, listed and labeled for series-connected short-circuit rating by an NRTL.

I. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 DISTRIBUTION PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

C. Panelboards: NEMA PB 1, power and feeder distribution type.

D. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.

E. Mains: Circuit breaker, Fused switch, and Lugs only.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Plug-inBolt-on circuit breakers.

G. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

H. Branch Overcurrent Protective Devices: Fused switches.

I. Contactors in Main Bus: NEMA ICS 2, Class A, electrically and/or mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
2. External Control-Power Source: 120-V branch circuit.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

C. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

D. Mains: Circuit breaker or lugs only.

E. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

F. Contactors in Main Bus: NEMA ICS 2, Class A, electrically and/or mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
2. External Control-Power Source: 120-V branch circuit.

G. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

H. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

C. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time pickup levels.
    c. Long- and short-time time adjustments.
    d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
6. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
7. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Compression and Mechanical style, suitable for number, size, trip ratings, and conductor materials.
c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
d. Ground-Fault Protection: Remote-mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
e. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
f. Shunt Trip: 120 and/or 24 V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
h. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
i. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
k. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
l. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
m. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
n. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

D. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

1. Fuses, and Spare-Fuse Cabinet: Comply with requirements specified in Division 26 Section "Fuses."
2. Fused Switch Features and Accessories: Standard ampere ratings and number of poles.
3. Auxiliary Contacts: One normally open and normally closed contact(s) that operate with switch handle operation.

2.5 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NECA 407 and/or NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Install panelboards and accessories according to NECA 407 and/or NEMA PB 1.1.

B. Equipment Mounting: Install panelboards on concrete bases, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
2. For panelboards, 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 panelboards.
5. Attach panelboard to the vertical finished or structural surface behind the panelboard.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

E. Mount top of trim [90 inches (2286 mm) above finished floor unless otherwise indicated.

F. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

G. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

H. Install filler plates in unused spaces.

I. Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.

J. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

K. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. The CxA must be provided with a least two weeks notice of any scheduled field quality control testing.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

E. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

F. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
    c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

G. Panelboards will be considered defective if they do not pass tests and inspections.

H. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.

1. Measure as directed during period of normal system loading.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.6 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

SECTION 262713 - ELECTRICITY METERING

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 equipment for electricity metering by utility company and electricity metering by Owner.

1.3 DEFINITIONS

A. KY Pulse: Term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay opening and closing in response to the rotation of the disk in the meter.

1.4 SUBMITTALS

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

B. Shop Drawings: For electricity-metering equipment.

1. Dimensioned plans and sections or elevation layouts.
2. Wiring Diagrams: For power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features.

C. Field quality-control reports.

D. Operation and Maintenance Data. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Application and operating software documentation.
2. Software licenses.
3. Software service agreement.
4. Hard copies of manufacturer's operating specifications, design user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy Submittal.

1.5 QUALITY ASSURANCE

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

1.6 DELIVERY, STORAGE, AND HANDLING

A. Receive, store, and handle modular meter center according to NECA 400.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Architect and Construction Manager no fewer than two (2) days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Architect's and Construction Manager's written permission.

1.8 COORDINATION

A. Electrical Service Connections: Coordinate with utility companies and components they furnish as follows:

1. Comply with requirements of utilities providing electrical power services.
2. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

1.9 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for two (2) years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two (2) years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide thirty (30) days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade his computer equipment if necessary.

PART 2 - PRODUCTS

2.1 EQUIPMENT FOR ELECTRICITY METERING BY UTILITY COMPANY

A. Meters will be furnished by utility company.

B. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.

C. Meter Sockets: Comply with requirements of electrical-power utility company.

D. Meter Sockets: Steady-state and short-circuit current ratings shall meet indicated circuit ratings.

E. Modular Meter Center: Factory-coordinated assembly of a main service terminal box with lugs only and/or disconnect device, wireways, tenant meter socket modules, and tenant feeder circuit breakers arranged in adjacent vertical sections. Assembly shall be complete with interconnecting buses and other features as specified below.

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one (1) of the following:

   a. Eaton Electrical Inc.; Cutler-Hammer Business Unit
   b. General Electric Company; GE Consumer & Industrial - Electrical Distribution
   c. Siemens Energy & Automation, Inc.
   d. Square D; a brand of Schneider Electric

2. Comply with requirements of utility company for meter center.
3. Housing: NEMA 250, Type 3R enclosure.
4. 100,000 A symmetrical at rated voltage.
5. Main Disconnect Device: Circuit breaker, series-combination rated for use with downstream feeder and branch circuit breakers.
6. Main Disconnect Device: Fusible switch, series-combination rated by circuit-breaker manufacturer to protect downstream feeder and branch circuit breakers.
7. Tenant Feeder Circuit Breakers: Series-combination-rated molded-case units, rated to protect circuit breakers in downstream tenant and to house loadcenters and panelboards that have 22,000-A interrupting capacity.

   a. Identification: Complying with requirements in Section 260553 "Identification for Electrical Systems" with legend identifying tenant's address.
   b. Physical Protection: Tamper resistant, with hasp for padlock.

8. Meter Socket: Rating coordinated with indicated tenant feeder circuit rating.
9. Surge Protection: For main disconnect device, comply with requirements in Division 26 Section "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with equipment installation requirements in NECA 1.

B. Install meters furnished by utility company. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extend grounding connections as required by utility company.

C. Install modular meter center according to NECA 400 switchboard installation requirements.

3.2 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Series Combination Warning Label: Self-adhesive type, with text as required by NFPA 70.
2. Equipment Identification Labels: Adhesive film labels with clear protective overlay. For residential meters, provide an additional card holder suitable for printed, weather-resistant card with occupant's name.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Connect a load of known kilowatt rating, 1.5 kW minimum, to a circuit supplied by metered feeder.
2. Turn off circuits supplied by metered feeder and secure them in off condition.
3. Run test load continuously for 8 hours minimum, or longer, to obtain a measurable meter indication. Use test-load placement and setting that ensures continuous, safe operation.
4. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.

C. Electricity metering will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 262713

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist-locking receptacles.
3. Wall-box motion sensors.
4. Snap switches and wall-box dimmers.
5. Wall switch sensor light switches with dual technology sensors.
6. Digital timer light switches

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. TVSS: Transient voltage surge suppressor.

F. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

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

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.6 COORDINATION

A. Receptacles for Owner-Furnished Equipment: Match plug configurations.

1. Cord and Plug Sets: Match equipment requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
3. Leviton Mfg. Company Inc. (Leviton).
4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2 STRAIGHT BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; 5351 (single), 5352 (duplex).
b. Hubbell; HBL5351 (single), CR5352 (duplex).
c. Leviton; 5891 (single), 5352 (duplex).
d. Pass & Seymour; 5381 (single), 5352 (duplex).

2.3 GFCI RECEPTACLES

A. General Description: Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; GF20.
b. Pass & Seymour; 2084.

2.4 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; L520R.
b. Hubbell; HBL2310.
c. Leviton; 2310.
d. Pass & Seymour; L520-R.

2.5 SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. Switches, 120/277 V, 20 A:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way), 2224 (four way).
b. Hubbell; CS1221 (single pole), CS1222 (two pole), CS1223 (three way), CS1224 (four way).
c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).
d. Pass & Seymour; 20AC1 (single pole), 20AC2 (two pole), 20AC3 (three way), 20AC4 (four way).

C. Pilot Light Switches, 20 A:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; 2221PL for 120 V and 277 V.
b. Hubbell; HPL1221PL for 120 V and 277 V.
c. Leviton; 1221-PLR for 120 V, 1221-7PLR for 277 V.
d. Pass & Seymour; PS20AC1-PLR for 120 V.

3. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."

D. Key-Operated Switches, 120/277 V, 20 A:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; 2221L.
b. Hubbell; HBL1221L.
c. Leviton; 1221-2L.
d. Pass & Seymour; PS20AC1-L.

3. Description: Single pole, with factory-supplied key in lieu of switch handle.

E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; 1995.
b. Hubbell; HBL1557.
c. Leviton; 1257.
d. Pass & Seymour; 1251.

F. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; 1995L.
b. Hubbell; HBL1557L.
c. Leviton; 1257L.
d. Pass & Seymour; 1251L.

2.6 WALL-BOX DIMMERS

A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.

C. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.

1. 600 W; dimmers shall require no derating when ganged with other devices. Illuminated when "OFF."

D. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.7 OCCUPANCY SENSORS

A. Wall-Switch Sensors:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:

    a. Cooper; 6111 for 120 V, 6117 for 277 V.
    b. Hubbell; WS1277.
    c. Leviton; ODS 10-ID.
    d. Pass & Seymour; WS3000.
    e. Watt Stopper (The); WS-200.

3. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).

B. Wall-Switch Sensors:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:

    a. Hubbell; AT120 for 120 V, AT277 for 277 V.
    b. Leviton; ODS 15-ID.

3. Description: Adaptive-technology type, 120/277 V, adjustable time delay up to 20 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).

C. Long-Range Wall-Switch Sensors:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:

    a. Hubbell; ATP1600WRP.
    b. Leviton; ODWWV-IRW.
    c. Pass & Seymour; WA1001.
    d. Watt Stopper (The); CX-100.

3. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, with a minimum coverage area of 1200 sq. ft. (111 sq. m).

D. Long-Range Wall-Switch Sensors:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:

a. Hubbell; ATD1600WRP.
b. Leviton; ODW12-MRW.
c. Watt Stopper (The); DT-200.

3. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, and a minimum coverage area of 1200 sq. ft. (111 sq. m).

E. Wide-Range Wall-Switch Sensors:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:

a. Hubbell; ATP120HBRP.
b. Leviton; ODWHB-IRW.
c. Pass & Seymour; HS1001.
d. Watt Stopper (The); CX-100-3.

3. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 150-degree field of view, with a minimum coverage area of 1200 sq. ft. (111 sq. m).

2.8 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Plate-Securing Screws: Stainless, tamper resistant with trident pan head matching current building standard.
2. Material for Finished Spaces: Brushed stainless.
3. Material for Unfinished Spaces: Brushed stainless for flush box installations, raised galvanized for surface box installations.
4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in wet locations while in use.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, thermoplastic with lockable cover.

2.9 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Rectangular, solid brass with satin finish.

D. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.

E. Voice and Data Communication Outlet: Two modular, keyed, color-coded, RJ-45 Category 5e jacks for UTP cable.

2.10 EPO MUSHROOM SWITCHES

A. Pushbuttons: NEMA ICS 2; Heavy duty, Oil-tight and dust-tight without boot, Chrome plated bezel, EMERG. STOP in front cover, Red mushroom style actuator.

B. Contact Blocks: Stacked mounting with single screw installation, color coded with clear window for contact status. Furnish with two N.O. and two N.C. contacts.

C. Activation: Two-position, push to activate, key to return to normal state.

2.11 FINISHES

A. Color: Wiring device catalog numbers in Section Text do not designate device color.

1. Wiring Devices Connected to Normal Power System: Ivory and/or as selected by Architect, unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: Red.
3. TVSS Devices: Blue.
4. Isolated-Ground Receptacles: Orange and/or as specified above, with orange triangle on face.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Coordination with Other Trades:

1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

a. Cut back and pigtail, or replace all damaged conductors.
b. Straighten conductors that remain and remove corrosion and foreign matter.

c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
10. Install GFCI devices in all wet locations.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."

1. Receptacles and Switches: Identify panelboard and circuit number from which served. Use self-adhesive labels with black lettering on white field mounted on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
   1. Test Instruments: Use instruments that comply with UL 1436.
   2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:

   1. Line Voltage: Acceptable range is 105 to 132 V.
   2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
   3. Ground Impedance: Values of up to 2 ohms are acceptable.
   4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
   5. Using the test plug, verify that the device and its outlet box are securely mounted.
   6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Test straight blade convenience outlets in patient-care areas and hospital-grade convenience outlets for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz. (115 g).

END OF SECTION 262726

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

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

1.5 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Include evidence of NRTL listing for series rating of installed devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Submit on translucent log-log graph paper.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

C. Qualification Data: For qualified testing agency.

D. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Field quality-control reports.

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Manufacturer's field service report.

G. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Submit on translucent log-log graph paper.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. 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.

E. Comply with NFPA 70.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
2. Altitude: Not exceeding 6600 feet (2010 m).

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Architect and Construction Manager no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Architect and Construction Manager written permission.
4. Comply with NFPA 70E.

1.8 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.9 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two for each size and type.
3.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

C. Type HD, Heavy Duty, Single Throw, 600-V ac and 240-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac and 240-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. Type HD, Heavy Duty, Double Throw, 600-V ac and 240-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

F. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Mechanical and/or Compression type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.2 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

C. Type HD, Heavy Duty, Single Throw, 600-V ac and 240-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac and 240-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. Type HD, Heavy Duty, Double Throw, 600-V ac and 240-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

F. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
4. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
5. Hookstick Handle: Allows use of a hookstick to operate the handle.
6. Lugs: Mechanical and/or Compression type, suitable for number, size, and conductor material.

2.3 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Kitchen and/or Wash-Down Areas: NEMA 250, Type 4X.
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
6. Hazardous Areas Indicated on Drawings: NEMA 250,[Type 9.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

E. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
    c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified

END OF SECTION 262816

SECTION 262923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

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 separately enclosed, pre-assembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. CE: Conformite Europeene (European Compliance).

C. CPT: Control power transformer.

D. EMI: Electromagnetic interference.

E. IGBT: Insulated-gate bipolar transistor.

F. LAN: Local area network.

G. LED: Light-emitting diode.

H. MCP: Motor-circuit protector.

I. NC: Normally closed.

J. NO: Normally open.

K. OCPD: Overcurrent protective device.

L. PCC: Point of common coupling.

M. PID: Control action, proportional plus integral plus derivative.

N. PWM: Pulse-width modulated.

O. RFI: Radio-frequency interference.

P. TDD: Total demand (harmonic current) distortion.

Q. THD(V): Total harmonic voltage demand.

R. VFC: Variable-frequency motor controller.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

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

1.5 SUBMITTALS

A. Product Data: For each type and rating of VFC indicated. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, and furnished specialties and accessories.

B. LEED Submittals:

1. Product Data for Credit EA 5: For continuous metering equipment for energy consumption.

C. Shop Drawings: For each VFC indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Each installed unit's type and details.
b. Factory-installed devices.
c. Enclosure types and details.
d. Nameplate legends.
e. Short-circuit current (withstand) rating of enclosed unit.
f. Features, characteristics, ratings, and factory settings of each VFC and installed devices.
g. Specified modifications.

2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.

D. Harmonic Analysis Study and Report: Comply with IEEE 399 and NETA Acceptance Testing Specification; identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible operating scenarios, including recommendations for VFC input filtering to limit TDD and THD(V) at each VFC to specified levels.

E. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

F. Seismic Qualification Certificates: For VFCs, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.

G. Product Certificates: For each VFC, from manufacturer.

H. Source quality-control reports.

I. Field quality-control reports.

J. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and MCP trip settings.
2. Manufacturer's written instructions for setting field-adjustable overload relays.
3. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
4. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

K. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.

L. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

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

C. Comply with NFPA 70.

D. IEEE Compliance: Fabricate and test VFC according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

1.7 DELIVERY, STORAGE, AND HANDLING

A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and connect factory-installed space heaters to temporary electrical service.

1.8 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than 14 deg F and not exceeding 104 deg F.
2. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
3. Humidity: Less than 95 percent (noncondensing).
4. Altitude: Not exceeding 3300 feet (1005 m).

1.9 COORDINATION

A. Coordinate features of motors, load characteristics, installed units, and accessory devices to be compatible with the following:

1. Torque, speed, and horsepower requirements of the load.
2. Ratings and characteristics of supply circuit and required control sequence.
3. Ambient and environmental conditions of installation location.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

1.11 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. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Refer to sections 2.5 through 2.9 of specification section 262419 “Motor-Control Centers” for general VFC requirements.

2.2 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 3R.
3. Kitchen Areas: Type 4X, stainless steel.
4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

2.3 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.

1. Test each VFC while connected to a motor that is comparable to that for which the VFC is rated.
2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

B. VFCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance.

B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

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

3.2 INSTALLATION

A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Wall-Mounting Controllers: Install VFCs on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted

to wall. For controllers not on walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."

C. Roof-Mounting Controllers: Install VFC on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.

1. Curbs and roof penetrations are specified in Division 07 Section "Roof Accessories."
2. Structural-steel channels are specified in Division 26 Section "Hangers and Supports for Electrical Systems."

D. Seismic Bracing: Comply with requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

F. Install fuses in each fusible-switch VFC.

G. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses."

H. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

I. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

J. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFC with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices and facility's central-control system. Comply with requirements in Division 26 Section "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect and Construction Manager before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Substantial Completion.
    c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. VFCs will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.7 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect and Construction Manager before increasing settings.

D. Set the taps on reduced-voltage autotransformer controllers.

3.8 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION 262923

SECTION 263213 - ENGINE GENERATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Provide labor, materials, services, equipment, and transportation necessary for complete and operational factory tested, paralleled electrical generation systems as indicated on Contract Drawings and specified herein, including, but not limited to the following:

1. Battery charger.
2. Engine-generator set.
3. Paralleling capability.
4. Enclosed muffler.
5. Exhaust piping external to set.
6. System controller.
7. Outdoor enclosure.
8. Remote annunciator.
9. Remote stop switch.
10. Starting battery.
11. System commissioning.

B. Related Sections include the following:

1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

1.2 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

B. Steady-State Voltage Modulation: The uniform cyclical variation of voltage within the operational bandwidth, expressed in Hertz or cycles per second.

1.3 SUBMITTALS

A. Product Data: Include the following:

1. Data on features, components, accessories ratings and performance.
2. Thermal damage curve for generators.
3. Time-current characteristic curves for generator protective device.
4. Certified generator sets fuel consumption curve.
5. Evidence of UL2200 Listing.
6. Evidence of EPA emissions certification for diesel gas configurations.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components and location and size of each field connection.

1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.

2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
4. Wiring Diagrams: Power, signal, and control wiring.

C. Welding certificates.

D. Manufacturer Seismic Qualification Certification: Submit certification that engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces Include the following:

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

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

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Submit Qualification Data for testing agency, including a sample of a representative Field Quality Control Test Report.

F. Certified summary of prototype-unit test report.

G. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.

H. Certified Summary of Performance Tests: Demonstrate compliance with specified requirement to meet performance criteria for sensitive loads.

I. Test Reports:

1. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements. Systems not tested in parallel at the factory will not be accepted.
2. Report of sound generation.
3. Report of exhaust emissions showing compliance with EPA and other applicable regulations.
4. Report of UL2200 Listing.
5. Field quality-control test reports.

J. Certification of Torsional Vibration Compatibility: Comply with NFPA 110.

K. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 and Division 26, include the following:

1. List of tools and replacement items recommended to be stored at the Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

L. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1. Maintenance Proximity: Not more than 4 hours' normal travel time from Installer's place of business to Project site.
2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.

B. Manufacturer Qualifications: A qualified manufacturer that has produced and commissioned a minimum of one thousand (1000) integrated paralleled systems. Maintain, within fifty (50) miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.

C. Source Limitations: Obtain packaged generator sets and auxiliary components through one (1) source from a single manufacturer.

D. Product Options: Drawings indicate size, profiles, and dimensional requirements of packaged generator sets and are based on the specific system indicated. Refer to Section 016000 "Product Requirements."

E. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX for welding exhaust and cooling system piping.

F. 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.

G. Comply with NFPA 37.

H. Comply with NFPA 70.

I. Comply with NFPA 99.

J. Comply with NFPA 110 requirements for Level 1 emergency power supply system.

K. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

L. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver engine generator system and auxiliary system components to their final locations in protective wrappings, containers and other protection that will exclude dirt and moisture and prevent damage from construction operations. Remove protection only after equipment is safe from such hazards.

1.7 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. Alternate Bi-Fuel Bid must also include single source warranty responsibility for all components including bi fuel accessories. Third party warranties will not be accepted.

1. Warranty Period: Five (5) years from date of Substantial Completion.

1.8 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide twelve (12) months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, paralleling, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Maintenance agreements shall include parts and supplies as used in manufacture and installation of original equipment.

1.9 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 (1) for every ten (10) of each type and rating, but not less than one (1) of each.
2. Indicator Lamps: Two (2) for every six (6) of each type used, but not less than two (2) of each.
3. Filters: One (1) set each of lubricating oil, fuel, and combustion-air filters.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cummins

2. Kohler Generators

3. Generac

2.2 ENGINE-GENERATOR SET

A. Packaged engine-generator set shall be a coordinated assembly of compatible components.

B. Power Output Ratings: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing.

C. Output Connections: Three-phase, four-wire.

D. Safety Standard: Comply with ASME B15.1.

E. Nameplates: Each major system component shall be equipped with a nameplate to identify manufacturer's name and address, and model and serial number of component.

F. Fabricate engine-generator-set mounting frame and attachment of components to resist generator-set movement during a seismic event when generator-set mounting frame is anchored to building structure.

G. Mounting Frame: Adequate strength and rigidity to maintain alignment of mounted components without depending on concrete foundation. Mounting frame shall be free from sharp edges and corners and shall have lifting attachments arranged for lifting with slings without damaging components.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

2.3 GENERATOR-SET PERFORMANCE

A. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.

1. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.

B. Steady-State Voltage Operational Bandwidth: Two percent (2%) of rated output voltage from no load to full load.

C. Steady-State Voltage Modulation Frequency: Less than 1 Hz.

D. Transient Voltage Performance: Not more than ten percent (10%) variation for fifty percent (50%) step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.

E. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.

F. 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.

G. Transient Frequency Performance: Less than 2-Hz variation for a fifty percent (50%) step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.

H. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed two percent (2%) total with no slot ripple. The telephone influence factor, determined according to NEMA MG 1, shall not exceed fifty percent (50%).

I. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, the system shall supply a minimum of three hundred percent (300%) of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.

J. Excitation System: Permanent Magnet Generator. Performance shall be unaffected by voltage distortion caused by nonlinear load.

K. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.4 SERVICE 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: Zero to ninety-five percent (0-95%).
3. Altitude: Sea level to 1000 feet.

2.5 ENGINE

A. Fuel: Deisel.

B. Rated Engine Speed: 1800 rpm.

C. Maximum Piston Speed for V-10 Cylinder Arrangement: 1677 fpm.

D. Lubrication System: The following items are mounted on engine or skid:

1. Filter and Strainer: Rated to remove ninety percent (90%) of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

E. Engine Fuel System:

1. Designed to operate on Diesel.

F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

G. Governor: Adjustable isochronous, with speed sensing.

H. Pipe crankcase ventilation fumes directly into engine intake to burn them and reduce unwanted emissions.

I. Engine must meet EPA emissions standards for diesel engines. Evidence of EPA certification must be submitted prior to engineering acceptance.

2.6 ENGINE COOLING SYSTEM

A. Description: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.

B. Radiator: Rated for specified coolant.

C. Coolant: Solution of fifty percent (50%) ethylene-glycol-based antifreeze and fifty percent (50%) water, with anticorrosion additives as recommended by engine manufacturer.

D. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.

E. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

F. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.

1. Rating: 50-psig maximum working pressure with coolant at 180 deg F (82 deg C), and non-collapsible under vacuum.
2. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

G. Coolant piping external to engine-generator set. Use ASTM B 88, Type L copper tubing with brazed joints, sized as recommended by engine manufacturer. Refer to Plumbing Drawings for basic piping installation and joint construction.

2.7 FUEL SUPPLY SYSTEM

A. Deisel.

2.8 ENGINE EXHAUST SYSTEM

A. Muffler: Critical type, sized as recommended by engine manufacturer. Muffler must be installed inside the generator enclosure.

1. Provide muffler with drain outlet through a petcock.

B. Connection from Engine to Exhaust System: Flexible section of corrugated stainless-steel pipe, minimum 18-inch length from exhaust outlet to muffler with flanged pipe connections.

C. Connection from Exhaust Pipe to Muffler: Stainless-steel expansion joint with liner.

D. Exhaust Piping External to Engine: ASTM A 53, Schedule 40, welded, black steel, with welded joints and fittings.

2.9 COMBUSTION-AIR INTAKE

A. Description: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

2.10 STARTING SYSTEM

A. Description: 24-V electric, with negative ground and including the following items:

1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Environmental Conditions" Paragraph in "Service Conditions" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: As required by NFPA 110 for system level specified
4. Battery: Adequate capacity within ambient temperature range specified in "Environmental Conditions" Paragraph in "Service Conditions" Article to provide specified cranking cycle at least three (3) times without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in "Environmental Conditions" Paragraph in "Service Conditions" Article. Include accessories required to support and fasten batteries in place.
7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:

    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
    c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus ten percent (+/- 10%).
    d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
    e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
    f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.11 CONTROL AND MONITORING

A. Functional Description: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one (1) or more separate automatic transfer switches initiate starting and stopping of the generator set. When mode-selector switch is switched to the on position, the generator set starts. The off position of the same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down the generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down the generator set.

B. Functional Description: Switching on-off switch on the generator control panel to the on position starts the generator set. The off position of the same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down the generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down the generator set.

C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.

D. Indicating and protective devices and controls shall include those required by NFPA 110 for a Level 1 system, and the following:

1. Digital Indicating and Protective Devices and Controls:

a. AC voltmeter.
b. AC ammeter.
c. AC frequency meter: dial type.
d. DC voltmeter (alternator battery charging).
e. Engine-coolant temperature gage.
f. Engine lubricating-oil pressure gage.
g. Engine lube oil temperature.
h. Running-time meter.
i. Ammeter-voltmeter, phase-selector switch(es).
j. Generator-voltage adjusting rheostat.
k. Upper and lower meter scale indicator lights.
l. Start-stop switch.
m. Overspeed shutdown device.
n. Coolant high-temperature shutdown device.
o. Coolant low-level shutdown device.
p. Oil low-pressure shutdown device.
q. Auto/Off/Test switch. Test mode shall automatically start unit without interrupting normal electrical supply.
r. Overspeed shutdown device with LED status indicator which lights when overspeed condition has occurred as cause of shutdown.
s. Coolant high-temperature shutdown device with LED status indicator which lights when pre-alarm operating temperature has been reached and stays lit when shutdown occurs.
t. Coolant low-level shutdown device with LED status indicator which lights when low coolant level causes shutdown.
u. Oil low-pressure shutdown device with LED status indicator which lights when pre-alarm oil pressure condition has been reached and stays lit when shutdown occurs.
v. Overcrank shutdown device with LED status indicator which indicates engine has failed to start after 60 second cranking period.
w. Lamp test switch and audible alarm with silencer switch.
x. Low coolant temperature alarm with LED status indicator which indicates failure of block heater.
y. LED status indicator for “switch off”, which indicates when control switch has been placed in “off” position.
z. LED status indicator for “system ready”, indicating no malfunctions detected.
aa. Generator overload.

E. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

F. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals.

G. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.

H. 12/24 Volt Remote Annunciator Panel: With lights, audible alarm, alarm switch and lamp test switch, in accordance with NFPA 110, Level 1, to monitor the following conditions:

1. Line power.
2. Generator power.
3. System ready (in auto position).
4. Alarm switch off.
5. Generator switch off.
6. Emergency stop.
7. Engine high-temperature shutdown.
8. Lube-oil low-pressure shutdown.
9. Overspeed shutdown.
10. Remote emergency-stop shutdown.
11. Engine high-temperature pre-alarm.
12. Lube-oil low-pressure pre-alarm.
13. Low coolant level.
14. Overcrank shutdown.
15. Coolant low-temperature alarm.
16. Control switch not in auto position.
17. Battery-charger malfunction alarm.
18. Battery low-voltage alarm.
19. Battery high voltage alarm.

I. Remote Alarm Annunciator: Comply with NFPA 99. Labeled LED shall identify each alarm event. Common audible signal shall sound for alarm conditions. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

J. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.12 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Circuit Breaker: Molded-case, thermal-magnetic type, one hundred percent (100%) rated; complying with NEMA AB 1 and UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator rating.
3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.
5. Circuit breaker must be mounted inside generator enclosure. External circuit breakers or power breakers are not acceptable.

B. Generator Protector: Microprocessor-based unit that continuously monitors current level in each phase of generator output, integrates generator heating effect over time, and predicts when thermal damage of the alternator will occur. When signaled by the protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from the load circuits. Protector shall perform the following functions:

1. Initiates a generator overload alarm when the generator has operated at an overload equivalent to one hundred ten percent (110%) of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
2. Under single or three-phase fault conditions, regulates the generator to three hundred percent (300%) of rated full-load current for up to 10 seconds.
3. As the overcurrent heating effect on the generator approaches the thermal damage point of the unit, the protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

C. Ground-Fault Indication: Comply with NFPA 70, Article 700.7(D). Integrate ground-fault alarm indication with other generator-set alarm indications.

D. Provide generator output breaker with one N.C. and one N.O. contact indicating breaker status. This status indication shall signal an alarm to the remote annunciator panel to indicate a “Generator Output Breaker Open” alarm. The remote annunciator panel shall be equipped with a single summary alarm wired to the building BMS system indicating a “Generator Trouble” alarm.

2.13 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1 and specified performance requirements.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to one hundred twenty-five percent (125%) of rating, and heat during operation at one hundred ten percent (110%) of rated capacity.

F. Excitation shall use no slip or collector rings, or brushes, and shall be arranged to sustain generator output under short-circuit conditions as specified.

G. Enclosure: Dripproof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.

1. Adjusting rheostat on control and monitoring panel shall provide plus or minus five percent (+/-5%) adjustment of output-voltage operating band.
2. Provide with under-frequency protection and moisture-resistive protection.
3. Regulation shall be within plus or minus two percent (+/-2%) of rated voltage from no load to full load.
4. On application of rated load at rated power factor, instantaneous voltage dip shall NOT exceed twenty percent (20%), with recovery within 1 second.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: Twelve percent (12%), maximum.

M. Provide Permanent Magnet Generator (PMG) system.

N. Alternator shall be self-ventilated, one-piece cast aluminum alloy, uni-directional internal fan shall provide high volume, low noise air delivery with broad range, 12-load reconnectable, four-pole rotating field unit.

O. Temperature rise shall be within NEMA MG1-22.40, IEEE and ANSI Standards for standby duty at rated output.

P. Provide front-end mounted junction box for load connections. Junction box shall have space to mount regulator and voltage adjust rheostat inside box and to relocate same to opposite side without unit modification.

Q. Locked Rotor kVA: Total available skVA shall be minimum 6,600 at thirty-five percent (35%) voltage dip (1,650 skVA for each unit). Ninety percent (90%) sustained voltage ratings will not be accepted.

2.14 SYSTEM CONTROLLER (PM-SC)

A. The power manager system controller shall be an integrated microprocessor-based solution providing full digital integration with the generator controllers. The system controller shall utilize standard hardware and firmware manufactured by the generator supplier. The use of PLC based solutions will be considered less desirable due to reliability and support concerns posed by custom hardware/custom software solutions. A preference will be shown for designs that use the same control board hardware for both the generator(s) and system controller.

B. To ensure reliability and serviceability, the system controller shall be required to meet the same requirements as listed for the generator controller.

C. The control panel will provide a touch screen display to provide intuitive access to all user pertinent system status information.

D. The power for the system controller shall utilize redundant DC sources - an internal DC source inclusive of charging system and an external DC source from one of the generator's cranking batteries.

E. The system controller shall interface with the generators using digital communications. Any of the generator(s) status, operation conditions, or configuration parameters shall be accessible with a single point communication via the system controller.

F. The system controller shall provide sequence of facility load through three (3) priority loading (permissive) load steps and three (3) load shedding steps. These output parameters function based on the number of generators on the generator bus. The priority loading function provides sequential permissive contact closures enabling load to be transferred onto the generator in response to generators coming on-line. The load shedding function provides contact closures that disconnects load from the generator bus in response to a reduction in available generator capacity.

G. In addition to the communication requirements identified in Article 2.3.3, the system controller shall provide modem communications as standard.

H. The system controller and digital communications shall enhance system operation; neither shall be required to synchronize or operate the generators in parallel. Systems that require external control hardware or digital communications to synchronize and operate the generators in parallel are not acceptable.

I. The design of the system shall allow continued generator paralleled operation with failures to the system controller and/or communication. Control systems that have any systemic single point failure modes are not acceptable. This is inclusive of the reactive cross current and isochronous load sharing control loops.

J. The design of the system shall also provide generator start and paralleled operation with failures to the system controller and/or communication.

2.15 SOUND ATTENUATED OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Vandal-resistant, sound attenuated weatherproof steel housing, wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance including rear-hinged control panel door. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

1. Provide locking hasps (keyed alike) on engine side panels and control door.

B. Description: Prefabricated or pre-engineered enclosure with the following features:

1. Construction: Galvanized-steel, metal-clad, integral structural-steel-framed building erected on concrete foundation.
2. Structural Design and Anchorage: Wind resistant up to 100 mph.
3. Space Heater: Thermostatically controlled and sized to prevent condensation.
4. Louvers: Equipped with bird screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust, birds, and rodents.
5. Hinged Doors: With padlocking provisions.
6. Ventilation: Louvers equipped with bird screen and filter arranged to permit air circulation while excluding exterior dust, birds, and rodents.
7. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine-generator-set components.
8. Muffler Location: Within enclosure.
9. Enclosure Panelboard: Within enclosure, serving lights, receptacles, heaters, controls, batter charger and devices within enclosure. All electrical components and devices served by the enclosure panelboard shall be factory prewired to this panelboard.
10. Sound attenuation to reduce emitted sound to 76dBA at 23 feet.

C. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at one hundred ten percent (110%) of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.

D. Interior Lights with Switch: Factory-wired, vapor-proof type fixtures within housing; arranged to illuminate controls and accessible interior.

E. Convenience Outlets: Factory wired. Arrange for external electrical connection. Exterior Lighting: Contractor to supply and field install external lighting for generator enclosures.

2.16 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard enamel over corrosion-resistant pretreatment and compatible standard primer.

2.17 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

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. Generator Tests: Comply with IEEE 115.
3. Components and Accessories: Items furnished with installed unit that are not identical to those on tested prototype shall have been factory tested to demonstrate compatibility and reliability.

B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Full load run as a complete paralleled system for minimum 4 hours for base and alternate bids. Systems not factory paralleled and tested prior to shipment will not be accepted.
2. Parallel operation.
3. Maximum power.
4. Voltage regulation.
5. Transient and steady-state governing.
6. Single-step load pickup.
7. Safety shutdown.
8. Observation of Factory Tests: Provide fourteen (14) days' advance notice of tests and opportunity for observation of tests by Owner's representative.

C. Report factory test results within ten (10) days of completion of test.

D. Provide evidence of UL2200 listing for specified engine generators.

E. Provide evidence of EPA certification.

F. Provide factory warranty documentation for all equipment

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

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

3.2 CONCRETE BASES

A. Coordinate size and location of concrete bases.

3.3 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Install packaged engine generators level on concrete base.

1. Seismic Restraint: Mount packaged engine generator on restrained spring isolators to provide seismic restraint and vibration isolation. Seismic restraint and vibration isolation requirements. Seismic installation shall provide “withstand” requirement.

C. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

D. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

1. Verify that electrical wiring is installed according to manufacturer’s submittal and installation requirements in Division 26 Sections. Proceed with equipment start up only after wiring installation is satisfactory.
2. Provide interconnecting wiring between generator and automatic transfer switch(es).
3. Provide interconnecting wiring between generator and remote annunciator panel.
4. Provide interconnecting wiring between the SCR control system operating components, sensors, generator set, troubles and alarms.

3.4 CONNECTIONS

A. Piping installation requirements are specified on the Plumbing Drawings. Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:

1. Install fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
2. Connect cooling-system water supply and drain piping to gas engine heat exchangers. Install flexible connectors at connections to engine generator and remote radiator.
3. Connect fuel piping to engines with a gate valve and union.

a. Natural- and LP-gas piping, valves, and specialties for gas distribution outside and inside the building are specified on the Plumbing Drawings.

4. Connect exhaust-system piping to engines.

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical System".

C. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 IDENTIFICATION

A. Identify system components according to Section 260553 “Identification for Electrical Systems” and Plumbing Drawings.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections 7.15.2.1 and 7.22.1 (except for vibration baseline test). Certify compliance with test parameters. Tests shall be conducted by applying load (via load bank) to load side of automatic transfer switch or to other load point acceptable to Engineer.
2. Perform tests recommended by manufacturer.
3. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, the following:

    a. Single-step full-load pickup test.

4. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. 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.

5. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
6. 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.
7. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
8. Exhaust Emissions Test: Comply with applicable government test criteria.
9. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for fifty and one hundred percent (50 and 100%) step-load increases and decreases, and verify that performance is as specified.
10. Harmonic-Content Tests: Measure harmonic content of output voltage under twenty-five percent (25%) and at one hundred percent (100%) of rated linear load. Verify that harmonic content is within specified limits.
11. 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 (4) locations on the property line less than 23 feet from the enclosure, and compare measured levels with required values.

B. Coordinate tests with tests for transfer switches and run them concurrently.

C. Test instruments shall have been calibrated within the last twelve (12) months, traceable to standards of the National Institute for Standards and Technology, and adequate for making positive observation of test results. Make calibration records available for examination on request.

D. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

E. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

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

G. Remove and replace malfunctioning units and retest, reinspect as specified above.

H. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

I. Report results of tests and inspections in writing. Record adjustable relay 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.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

C. Complete installation and startup checks according to manufacturer's written instructions.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Section 017900 “Demonstration and Training”.

1. Coordinate this training with that for transfer switches.

END OF SECTION 263213

SECTION 263323.11 - INVERTER/BATTERY EQUIPMENT FOR EMERGENCY LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes the following central battery and power conversion equipment rated 600 V and less for emergency lighting:

1. Interruptible (slow-transfer) inverter/battery equipment.

1.3 DEFINITIONS

A. DDC: Direct digital control.

B. IBC: International Building Code.

C. Interruptible: As used in the Section Text, an off-line, passive-standby or line-interactive, inverter-only unit, with an intentional interruption of power to the load until an internal transfer switch picks up and transfers the load to the unit's inverter and internal battery source on loss of the "normal" source, and then retransfers to the "normal" source when it is restored. Transfer time can be "slow" (up to approximately 1.5 second or depending on manufacturer).

D. LED: Light-emitting diode.

E. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

F. OCPD: Overcurrent protective device.

G. PWM: Pulse-width modulated.

H. TDD: Total demand (harmonic current) distortion (also listed as "THD" in catalog data by manufacturers).

I. THD(V): Total harmonic voltage demand.

1.4 ACTION SUBMITTALS

A. Product Data: For each type and rating of inverter/battery equipment unit.

1. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, shipping splits, and furnished options, specialties, and accessories.

B. Shop Drawings: For each type and rating inverter/battery equipment unit.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, ventilation requirements, method of field assembly, components, and location and size of each field connection.
3. Include system one-line diagram, internal and interconnecting wiring; and diagrams for power, signal, and control wiring.
4. Include elevation, details, and legends of control and indication displays.
5. Include -circuit current (withstand) rating of unit.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around central battery equipment. Show central battery equipment layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

B. Qualification Data: For Installer and testing agency.

C. Seismic Qualification Certificates: For inverter/battery equipment, accessories, and components, from manufacturer.

1. Certificate of compliance.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Product Certificates: For each type of Inverter/battery equipment.

E. Harmonic Analysis Study and Report: Comply with IEEE 399 and NETA Acceptance Testing Specification; identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible operating scenarios, including recommendations for input filtering of inverter / battery equipment to limit TDD and THD(V) to specified levels.

F. Source quality-control reports.

G. Field quality-control reports.

H. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For inverter/battery equipment to include in emergency, operation, and maintenance manuals.

1. include the following:

a. Manufacturer's written instructions for testing inverter/battery equipment.

b. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
c. Manufacturer's written instructions for selecting and setting field-adjustable controls and status and alarm points

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to Owner.
1. Output Circuit Breakers: One for every 10 of each type and rating of each type.
2. Output Circuit Breaker Open/Tripped Alarm Contacts: One for every 10 supplied of each type.
3. Cabinet Ventilation Filters: One complete set.
4. Circuit Board: One spare circuit board for each critical circuit.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Testing Agency Qualifications: Member company of NETA or an NRTL acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment in fully enclosed vehicles.

B. Store equipment in spaces having environments controlled within manufacturers' written instructions for ambient temperature and humidity conditions for non-operating equipment.

1.10 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Less than 0 deg F or exceeding 104 deg F, with an average value exceeding 95 deg F over a 24-hour period.
2. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
3. Humidity: More than 95 percent (condensing).
4. Altitude: Exceeding 3300 feet.

B. Interruption of Existing Electrical Distribution Systems: Do not interrupt electrical distribution systems within facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Engineer or Owner no fewer than two days in advance of proposed interruption of electrical systems.
2. Indicate method of providing temporary electrical service.
3. Do not proceed with interruption of electrical systems without Engineer’s or Owner's written permission.
4. Comply with NFPA 70E.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for central battery equipment, including clearances between central battery equipment and adjacent surfaces and other items.

1.11 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

1.12 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace central battery equipment that fails in materials or workmanship within specified warranty period. Special warranty, applying to batteries only, applies to materials only, on a prorated basis, for period specified.

1. Warranty Period: Include the following warranty periods, from date of Substantial Completion:

a. Battery Equipment (excluding Batteries): One year(s).
b. Standard VRLA Batteries:

1) Full Warranty: 3 year(s).
2) Pro Rata: 6 years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: inverter/battery equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The designated central battery equipment shall be tested and certified by an NRTL as meeting ICC-ES AC 156 test procedure requirements.

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

2.2 INTERRUPTIBLE (SLOW-TRANSFER) INVERTER / BATTERY EQUIPMENT

A. General Requirements for Interruptible (Slow-Transfer) Inverter / Battery Equipment:

1. 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.
2. NRTL Compliance: Fabricate and label central battery equipment to comply with UL 924.

3. Comply with the IBC, NFPA 70, and NFPA 101.
4. Source Limitations: Obtain central battery equipment, including batteries, overcurrent protective devices, components, and accessories, from single source from single manufacturer.

B. Performance Requirements:

1. Slow-Transfer Inverter Battery Equipment: Passive-standby (off-line) system. Automatically sense loss of normal alternating-current (ac) supply and use an electromechanical transfer switch to transfer loads. Transfer in one second or less from normal supply to battery-inverter supply.
2. Automatic Operation:

    a. Normal Conditions: Supply the load with ac power flowing from normal ac power input terminals, bypassing inverter, with battery connected in parallel via rectifier/charger output.
    b. Abnormal Supply Conditions: If normal ac supply deviates from specified voltage, transfer switch operates and battery supplies constant, regulated ac power through the inverter to the load, with a momentary loss of power to the load.
    c. If normal power fails, transfer switch operates and battery supplies constant, regulated ac power through the inverter to the load, with a momentary loss of power to the load.
    d. If a fault occurs in system when being supplied by inverter and current flows in excess of the overload rating of inverter, inverter automatically protects itself against damage from overloads and short circuits by shutting down.
    e. When normal ac power is restored at input supply terminals of unit, controls automatically retransfer the load back to the normal ac supply, with a momentary loss of power to the load. Rectifier/charger then recharges battery.
    f. If normal power failure is prolonged (more than 90 minutes), integral low-voltage battery protective circuit disconnects battery and prevents battery from damage due to deep discharge.
    g. If battery becomes discharged, and when normal ac supply is again available, rectifier/charger recharges battery. When battery is fully charged, rectifier/charger automatically shifts to float-charge mode.
    h. If battery is disconnected, and normal ac power is available, central battery equipment continues to supply power to the load with no degradation of its regulation of voltage and frequency of output bus.

C. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of central battery equipment input voltage rating.
2. Input Frequency Tolerance: Plus or minus 3 or 5 percent of central battery equipment frequency rating.
3. Synchronizing Slew Rate: 1 Hz per second, maximum.
4. Minimum Off-Line Efficiency: 95 or 99 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 96 or 98 percent under any load or operating condition.
6. Ambient Temperature Rating (Other Than Batteries): Not less than 68 deg F and not exceeding 86 deg F.
7. Ambient Storage Temperature Rating (Other Than Batteries): Not less than minus 4 deg F and not exceeding 158 deg F
8. Ambient Temperature Rating (Batteries): Not less than 32 deg F and not exceeding 104 deg F.
9. Ambient Storage Temperature Rating (Batteries): Not less than 0 deg F and not exceeding 104 deg F.

10. Humidity Rating: Less than 95 percent (noncondensing).
11. Altitude Rating: Not exceeding 3300 feet.
12. Off-Line Overload Capability: 1.1 or 1.5 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.

D. Inverter and Controls Logic: Microprocessor based, isolated from all power circuits; provides complete self-diagnostics, periodic automatic testing and reporting; with alarms.

E. Controls and Indication:

1. Status Indication: Door-mounted, labeled LED indicators or digital screen displaying the following conditions:

a. Normal power available.
b. Status of system.
c. Battery charging status.
d. On battery power.
e. System fault.
f. External fault.

2. Remote Signal Interfaces:

a. Remote Indication Interface: A minimum of one programmable (Form C) dry-circuit relay output(s) (120-V ac, 2 A) for remote indication of the following:

1) Fault or status indication.
2) On bypass.
3) Low battery.

b. Communications Interface: Factory-installed hardware and software to enable a remote PC to program central battery equipment and monitor and display status and alarms.

1) Communications Ports: RS-232 or RS-485.
2) Compliance with ASHRAE 135: Controllers shall support serial MS/TP and Ethernet IP communications and shall be able to communicate directly via DDC system for HVAC RS-485 serial networks and Ethernet 10Base-T networks as a native device.

F. Self-Protection and Reliability Features:

1. Input transient protection by means of SPDs to provide protection against damage from supply voltage surges as defined in IEEE C62.45, Category B and C.
2. Integral, programmable, self-diagnostic and self-test circuitry; with alarms and logging.
3. Battery deep-discharge and self-discharge protection; with alarms.
4. Battery self-test circuitry; with alarms and logging.

G. Integral Input Disconnecting Means and OCPD: Thermal-magnetic circuit breaker, complying with UL 489.

1. Integrated Equipment Minimum Short-Circuit Current (Withstand) Rating: 22kA.

H. Inverter:

1. Description: Solid-state, high-frequency, PWM type, with the following operational features:

    a. Automatically regulate output voltage to within plus or minus 3 or 5 percent, for all load ranges and for maximum 25 percent step-load changes; regulation may increase to 8 percent for 100 percent step-load changes.
    b. Automatically regulate output frequency to within plus or minus 1 Hz, from no load to full load, at unity power factor, over the operating range of battery voltage.
    c. Output Voltage Waveform: Pure Sine wave with maximum 3 percent TDD throughout battery operating-voltage range, for 100 percent linear load.
    d. Load Power Factor: 0.5 lead to 0.5 lag.
    e. Inverter Overload Capability: 115 percent for 10 minutes; 150 percent surge for 10 seconds.

I. Batteries:

1. Description: seal lead batteries.

    a. Capable of sustaining full-capacity output of inverter unit for minimum of 90 minutes.

2. Battery Disconnect and OCPD: Manufacturer's standard.

J. Maintenance Bypass Systems:

1. Maintenance Bypass Mode: Internal; manual operation only; bypasses inverter/battery equipment power circuits (inverter and transfer switch); requires local operator selection at central battery equipment. Transfer and retransfer shall be make-before-break, without disrupting power to the load or causing system instabilities.
2. Maintenance Bypass Mode: External; manual operation only; bypasses central battery equipment completely; requires local operator selection at external switch enclosure remote from central battery equipment. Transfer and retransfer shall be make-before-break, without disrupting power to the load or causing system instabilities. Bypass Overload Capability: 1.5 times the base load current.

K. Integral Output Disconnecting Means and OCPD:

1. Single-Output OCPD: As scheduled on Drawings; manufacturer's standard ratings based on unit output ratings.
2. Multiple-Output OCPDs: Thermal-magnetic circuit breakers, complying with UL 489; voltage rating matching unit output voltage rating; 20 A, single pole.

2.3 ENCLOSURES

A. Central Battery Equipment Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1 steel cabinets with access to components through hinged doors with flush tumbler lock and latch.
2. Finish: Manufacturer's standard baked-enamel finish over corrosion-resistant prime treatment.

2.4 OPTIONAL AND ACCESSORY FEATURES

A. Factory-Installed Options and Accessories:

1. Multiple-Output Voltages: Supply unit branch circuits at different voltage levels if required. Transform voltages internally as required to produce indicated output voltages.
2. Split-Output Configuration: Divides output into normally on and normally off buses.
3. Auto-dialer.
4. Internal fax modem.
5. Audible alarm with silencer switch.
6. Remote Summary Alarm Panel: Labeled LEDs on panel faceplate shall indicate five basic status conditions. Audible signal indicates alarm conditions; silencing switch in face of panel silences signal without altering visual indication.

    a. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.
    b. Maximum Distance from Main Unit: 1000 feet.

7. Remote Meter Panel: Match equipment requirements of remote monitoring, controlling, and programming of central battery equipment.

    a. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.
    b. Maximum Distance from Main Unit: 150 feet.

2.5 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect assembled central battery equipment, by a qualified testing agency, according to UL 924. Affix standards organization's label. Include the following:

1. Functional test and demonstration of all functions, controls, indicators, sensors, and protective devices.
2. Full-load test.
3. Transient-load response test.
4. Overload test.
5. Power failure test.

B. Central battery equipment will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store central battery equipment according to NECA 411.

B. Examine areas, surfaces, and substrates to receive central battery equipment, with Installer present, for compliance with requirements for installation tolerances, structural support, ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment will be installed, before installation begins.

C. Examine equipment before installation. Reject equipment that is wet, moisture damaged, or mold damaged.

D. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

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

3.2 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, including recommendations for central battery equipment input filtering to limit TDD and THD(V) to specified levels.

B. Prepare a harmonic analysis study and report complying with IEEE 399 and with NETA Acceptance Testing Specification.

3.3 INSTALLATION

A. Coordinate layout and installation of inverter/battery equipment with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install inverter battery equipment and accessories according to NECA 411.

C. Wall-Mounted Inverter/ Battery Equipment: Install central battery equipment on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For units not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

D. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

F. Comply with NECA 1.

G. Wiring Method: Install cables in raceways except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used for low-voltage control and alarm wiring. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

H. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

I. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.4 CONNECTIONS

A. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated.

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. Separately Derived Systems: Make grounding connections to grounding electrodes and bonding connections to metallic piping systems as indicated; comply with NFPA 70.

C. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 CONTROL WIRING INSTALLATION

A. Install wiring between inverter/battery equipment and remote devices and facility's central-control system. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

3.6 IDENTIFICATION

A. Identify central battery equipment, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label inverter/battery equipment with engraved nameplates.
3. Label each separate cabinet, for multicabinet units.
4. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for central battery equipment, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of central battery equipment units.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. The CxA must be provided with a least two weeks notice of any scheduled field quality control testing.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections.

E. Acceptance Testing Preparation:

1. Inspect and Test Each Component:

    a. Inspect wiring, components, connections, and equipment installations. Test and adjust components and equipment.
    b. Test insulation resistance for all external branch circuit, feeder, control, and alarm wiring connected to central battery equipment element and component.
    c. Test continuity of each circuit.

F. Tests and Inspections:

1. Inspect central battery equipment, wiring, components, connections, and equipment installation. Test and adjust components and equipment.
2. Test insulation resistance for all external branch circuit, feeder, control, and alarm wiring connected to central battery equipment element and component.
3. Test continuity of each circuit.
4. Verify that input voltages and frequencies at central battery equipment locations are within voltage and frequency limits specified in Part 2. If outside this range, notify Engineer before closing input OCPDs.
5. Perform each visual and mechanical inspection and electrical test stated in manufacturer's written instructions and in NETA Acceptance Testing Specification, including specifically those for batteries, battery chargers, and UPS, regardless of the type of central battery equipment provided. Certify compliance with test parameters.
6. Perform a load-duration test at rated voltage and rated output current to verify the correct functional operation of the unit under full-load stable operating conditions for the minimum time limits required by UL 924. Monitor and record ambient temperature and temperatures within the unit.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of central battery equipment. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of central battery equipment 11 months after date of Substantial Completion.
    c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

G. Inverter battery equipment will be considered defective if it does not pass tests and inspections.

H. Prepare test and inspection reports, including a certified report that identifies central battery equipment and describes all test results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.8 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.9 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, and other adjustable parts.

C. Adjust the trip settings of thermal-magnetic circuit breakers with adjustable, instantaneous-trip elements; install fuses if not factory installed.

D. Set the automatic system test parameters.

E. Set field-adjustable, circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

3.10 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace central battery equipment whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.11 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain central battery equipment, and to use and reprogram microprocessor-based control, monitoring, and display functions.

END OF SECTION 263323.11

SECTION 263600 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes transfer switches rated 600 V and less, including the following:

1. Automatic transfer switches.

1.2 ACTION SUBMITTALS

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

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer and testing agency.

B. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems." Include the following:

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

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

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Features and operating sequences, both automatic and manual.

2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than 8 hours from time of notification.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain automatic transfer switches through one (1) source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with NEMA ICS 1.

F. Comply with NFPA 70.

G. Comply with NFPA 99.

H. Comply with NFPA 110.

I. Comply with UL 1008 unless the requirements of these Specifications are stricter.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:

1. Notify Owner no fewer than two (2) days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner’s written permission.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Contactor Transfer Switches:

a. Cummins
b. Eaton/Cutler Hammer
c. Emerson; ASCO Power Technologies, LP
d. Generac
e. GE Zenith Controls
f. Kohler
g. MTU
h. Russelectric, Inc.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding thirty percent (30%) of switch ampere rating, unless otherwise indicated.

B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008. Coordinate with main service ratings.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.

C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus two percent (+/- 2%) or better over an operating temperature range of minus 20 to plus 70 deg C.

D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Electrical Operation: Accomplish by a non-fused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 400 A and higher, shall have separate arcing contacts.

G. Neutral Terminal: Solid and fully rated, unless otherwise indicated.

H. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.

I. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

J. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Section 260553 "Identification for Electrical Systems."

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

K. Enclosures: General-purpose NEMA 250, Type 1 complying with NEMA ICS 6 and UL 508, unless otherwise indicated. Coordinate size, layout, and connection requirements with adjacent switchgear.

2.3 AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.

D. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.

E. Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

F. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.

G. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two (2) sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and seventy percent (70%) or more of nominal voltage.

H. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.

I. Automatic Transfer-Switch Features:

1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from eighty-five to one hundred percent (85-100%) of nominal, and dropout voltage is adjustable from seventy-five to ninety-eight percent (75-98%) of pickup value. Factory set for pickup at ninety percent (90%) and dropout at eighty-five percent (85%).
2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from 0 to 6 seconds, and factory set for 1 second.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from eighty-five to one hundred percent (85-100%) of nominal. Factory set for pickup at ninety percent (90%). Pickup frequency shall be adjustable from ninety to one hundred percent (90-100%) of nominal. Factory set for pickup at ninety-five percent (95%).
4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One (1) isolated and normally closed, and one (1) isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from seven (7) to thirty (30) days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is not available.

2.4 SOURCE QUALITY CONTROL

A. Factory test and inspect 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 complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Section 260548 "Vibration and Seismic Controls for Electrical Systems."

B. Wall-Mounting Switch.

C. Identify components according to Section 260553 "Identification for Electrical Systems."

D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 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 installation, including connections, and to assist in testing.
2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

    a. Check for electrical continuity of circuits and for short circuits.
    b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
    c. Verify that manual transfer warnings are properly placed.
    d. Perform manual transfer operation.

5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.

    a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    b. Simulate loss of phase-to-ground voltage for each phase of normal source.

c. Verify time-delay settings.
d. Verify pickup and dropout voltages by data readout or inspection of control settings.
e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for one (1) pole deviating by more than fifty percent (50%) from other poles.
g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

a. Verify grounding connections and locations and ratings of sensors.

B. Coordinate tests with tests of generator and run them concurrently.

C. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

D. Remove and replace malfunctioning units and retest as specified above.

E. Infrared Scanning: After Substantial Completion, but not more than sixty (60) days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch eleven (11) months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Section 017900 "Demonstration and Training."

B. Coordinate this training with that for generator equipment.

END OF SECTION 263600

SECTION 265119 - LED INTERIOR LIGHTING

PART 1 - 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 the following types of LED luminaires:
   1. Downlight.
   2. Recessed linear.
   3. Strip light.
   4. Surface mount, linear.
   5. Surface mount, nonlinear.
   6. Suspended, linear.
   7. Suspended, nonlinear.
   8. Materials.
   9. Finishes.
   10. Luminaire support.

B. Related Requirements:

   1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.
5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
6. Photometric data and adjustment factors based on laboratory tests[, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project] IES LM-79 and IES LM-80.

    a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
    b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Sustainable Design Submittals:

D. Samples: For each luminaire and for each color and texture with standard factory-applied finish.

E. Samples for Initial Selection: For each type of luminaire with custom factory-applied finishes.

1. Include Samples of luminaires and accessories involving color and finish selection.

F. Samples for Verification: For each type of luminaire.

1. Include Samples of luminaires and accessories to verify finish selection.

G. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings or approved equal.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches of the plane of the luminaires.
4. Structural members to which equipment or luminaires will be attached.
5. Initial access modules for acoustical tile, including size and locations.
6. Items penetrating finished ceiling, including the following:

a. Other luminaires.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Ceiling-mounted projectors.

7. Moldings.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

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

E. Product Certificates: For each type of luminaire.

F. Product Test Reports: For each luminaire, for tests performed by a qualified testing agency.

G. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

2. Refer to specifications 014823 Operation and Maintenance Data for additional O&G Requirements

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

C. Provide luminaires from a single manufacturer for each luminaire type.

D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

E. Mockups: For interior luminaires in room or module mockups, complete with power and control connections.

1. Obtain Architect's approval of luminaires in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE 7

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified[and the luminaire will be fully operational during and after the seismic event]."

2.2 LUMINAIRE REQUIREMENTS

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

B. Standards:

1. ENERGY STAR certified.
2. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
3. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
4. UL Listing: Listed for damp location.
5. Recessed luminaires shall comply with NEMA LE 4.
6. User Replaceable Lamps:

a. Bulb shape complying with ANSI C78.79.
b. Lamp base complying with ANSI C81.6 or IEC 60061-1.

C. CRI of minimum 80 CCT of 4000 K]

D. Rated lamp life of 50,000 hours to L70.

E. Lamps dimmable from 100 percent to 0 percent of maximum light output.

F. Internal driver.

G. Nominal Operating Voltage: 120 V ac, 24 V dc.

1. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

H. Housings:

1. Extruded-aluminum housing and heat sink.
2. Clear finish.

2.3 DOWNLIGHT

A. Minimum 1,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

B. Universal mounting bracket.

C. Integral junction box with conduit fittings.

D. Optics:

1. Fixed lens.
2. Medium light distribution.

2.4 LINEAR INDUSTRIAL

A. Minimum 5,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

B. Housing and heat sink rated to the following:

1. Class 1, Division 2 Group(s) A ,B, C and D.
2. NEMA 4X.
3. IP 54.
4. IP 66.
5. Marine and wet locations.
6. CSA C22.2 No 137.

2.5 RECESSED LINEAR

A. Minimum [1,500] [2,000] [3,000] <Insert number> lumens. Minimum allowable efficacy of [85] <Insert number> lumens per watt.

B. Integral junction box with conduit fittings.

2.6 STRIP LIGHT

A. Minimum [750] <Insert number> lumens. Minimum allowable efficacy of [75] [80] <Insert number> lumens per watt.

B. Integral junction box with conduit fittings.

2.7 SURFACE MOUNT, LINEAR

A. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.

B. Integral junction box with conduit fittings.

2.8 SURFACE MOUNT, NONLINEAR

A. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.

B. Integral junction box with conduit fittings.

2.9 SUSPENDED, LINEAR

A. Minimum 3,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

2.10 SUSPENDED, NONLINEAR

A. Minimum 3,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

B. Integral junction box with conduit fittings.

2.11 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:

1. [Tempered Fresnel glass] [prismatic glass] [diffuse glass] [clear glass] [prismatic acrylic] [clear, UV-stabilized acrylic]
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

1. Extruded-aluminum housing and heat sink.
2. Clear finish.

E. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage, and coating.
c. CCT and CRI for all luminaires.

2.12 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.13 LUMINAIRE SUPPORT

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage.

D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaire Support:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaire Support:

1. Attached to a minimum 20 gauge backing plate attached to wall structural members.
2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Mounted Luminaire Support:

1. Ceiling mount with two 5/32-inch-diameter aircraft cable supports adjustable to 120 inches in length.
2. Ceiling mount with [pendant mount] [four-point pendant mount] with 5/32-inch diameter aircraft cable supports adjustable to 120 inches in length.
3. Ceiling mount with hook mount.

H. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

I. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Comply with requirements for startup specified in Section 260943.16 "Addressable-Luminaire Lighting Controls."

B. Comply with requirements for startup specified in Section 260943.23 "Relay-Based Lighting Controls."

3.7 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265119

SECTION 265219 - EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Exit signs.
   2. Luminaire supports.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.

D. Fixture: See "Luminaire" Paragraph.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.

   1. Include data on features, accessories, and finishes.
   2. Include physical description of the unit and dimensions.
   3. Battery and charger for light units.
   4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
   5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.

      a. Testing Agency Certified Data: For all luminaires, photometric data certified by a qualified independent testing agency.

B. Shop Drawings: For nonstandard or custom luminaires.

   1. Include plans, elevations, sections, and mounting and attachment details.

2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches (300 mm) of the plane of the luminaires.
4. Structural members to which equipment will be attached.
5. Size and location of initial access modules for acoustical tile.
6. Items penetrating finished ceiling including the following:

    a. Other luminaires.
    b. Air outlets and inlets.
    c. Speakers.
    d. Ceiling-mounted projectors.
    e. Sprinklers.
    f. Access panels.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Product Certificates: For each type of luminaire.

D. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Product Test Reports: For each luminaire for tests performed by a qualified testing agency.

F. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

B. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

C. Mockups: For interior luminaires in room or module mockups, complete with power and control connections.

1. Obtain Architect's approval of luminaires and signs in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.9 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.

B. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Emergency Power Unit Batteries: 5 years from date of Substantial Completion. Full warranty shall apply for first year and prorated warranty for the remaining four years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

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

2.2 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

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

B. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.

C. Comply with NFPA 70 and Connecticut Fire Safety Code with 2009 and 2012 amendments.

D. Comply with NEMA LE 4 for recessed luminaires.

E. Comply with UL 1598 for fluorescent luminaires.

F. Lamp Base: Comply with ANSI C81.61 or IEC 60061-1.

G. Bulb Shape: Complying with ANSI C79.1.

H. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body.

1. Emergency Connection: Operate one lamp continuously at an output of 1100 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.
2. Operation: Relay automatically turns lamp on when power-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 from battery, and battery is automatically recharged and floated on charger.
3. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Less than 0 deg F (minus 18 deg C) or exceeding 104 deg F (40 deg C), with an average value exceeding 95 deg F (35 deg C) over a 24-hour period.
    b. Ambient Storage Temperature: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C).
    c. Humidity: More than 95 percent (condensing).
    d. Altitude: Exceeding 3300 feet (1000 m).

4. Test Push-Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.

    a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

5. Battery: Sealed, maintenance-free, nickel-cadmium or lead-acid type as scheduled.

6. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
7. Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
8. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

I. Refer to section 260923, Lighting Control Devices, fro requirements for UL924 emergency shunt relays.

2.3 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:
1. Operating at nominal voltage of 277 V ac.
2. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
3. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.
4. Master/Remote Sign Configurations:

    a. Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in LED power supply for power connection to remote unit.
    b. Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.
5. Exit Signs wired to emergency lighting power source (AC type): Shall be wired through a UL 924 listed relay providing connection to emergency lighting circuit with an alternate non-emergency circuit (normal lighting) to power the sign on a loss of the emergency circuit.

C. Photoluminescent Signs:
1. Use strontium oxide aluminate compound to store ambient light and release the stored energy when the light is removed. Include universal bracket for flush-ceiling, wall, or end mounting.
2. Unit shall be UL 924 listed for use above the door and for low-level applications for minimum 90 minute durations.
3. Furnish with extruded aluminum frame and concealed mounting hardware.
4. Chevrons shall be self-adhesive type, meeting NFPA requirements.
5. Unit shall carry 10 year warranty.

D. Specified Area of Refuge signs shall meet power and illumination requirements for exit signs. These shall be furnished with appropriate text and the universal symbol of accessibility (wheelchair symbol).

E. Specified Signs for Accessible Exit shall meet power and illumination requirements for exit signs. These shall be furnished with universal symbol of accessibility (wheelchair symbol) having a minimum height of 6 inches and meeting the requirements of IBC 1011.1.2.

2.4 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access:

1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit relamping without use of tools.
3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:

1. Prismatic or Clear, UV-stabilized acrylic.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
4. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

D. Housings:

1. Extruded aluminum or polycarbonate housing as scheduled.

E. Conduit: Rigid galvanized steel, minimum 3/4 inch (21 mm) in diameter.

2.5 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Support Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.

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

3.2 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire and emergency power unit weight.
2. Able to maintain luminaire position when testing emergency power unit.
3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.

E. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

F. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

G. Ceiling Grid Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Perform startup service:
1. Charge emergency power units and batteries minimum of 24 hours and conduct one-hour discharge test.

3.6 ADJUSTING

A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:

1. Inspect all luminaires. Replace lamps, emergency power units, batteries, signs, or luminaires that are defective.

a. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

2. Conduct short-duration tests on all emergency lighting.

END OF SECTION 265219

SECTION 265613 - LIGHTING POLES AND STANDARDS

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. Poles and accessories for support of luminaires.
2. Luminaire-lowering devices.

1.3 DEFINITIONS

A. EPA: Equivalent projected area.

B. Luminaire: Complete lighting fixture.

C. Pole: Luminaire-supporting structure, including tower used for large-area illumination.

D. Standard: See "Pole."

1.4 ACTION SUBMITTALS

A. Product Data: For each pole, accessory, and luminaire-supporting and -lowering device, arranged as indicated.

1. Include data on construction details, profiles, EPA, cable entrances, materials, dimensions, weight, rated design load, and ultimate strength of individual components.
2. Include finishes for lighting poles and luminaire-supporting devices.
3. Anchor bolts.
4. Manufactured pole foundations.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of poles and pole accessories.
4. Foundation construction details, including material descriptions, dimensions, anchor bolts, support devices, and calculations, signed and sealed by a professional engineer licensed in the state of installation.
5. Anchor bolt templates keyed to specific poles and certified by manufacturer.
6. Method and procedure of pole installation. Include manufacturer's written installations.

C. Samples: For each exposed lighting pole, standard, and luminaire-supporting device and for each color and texture specified.

1.5 INFORMATIONAL SUBMITTALS

A. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements according to AASHTO LTS-6-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations signed and sealed by a professional engineer.

B. Qualification Data: For Installer and testing agency.

C. Seismic Qualification Certificates: For accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Material Test Reports:

1. For each foundation component, by a qualified testing agency.
2. For each pole, by a qualified testing agency.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranty: Manufacturer's standard warranty.

H. Soil test reports

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For poles and luminaire-lowering devices to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include pole inspection and repair procedures.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Pole repair materials.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM C 1093 for foundation testing.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.

B. Store poles on decay-resistant skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch deep. Do not apply tools to section of pole to be installed below finished grade.

D. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.

E. Retain factory-applied pole wrappings on metal poles until right before pole installation. Handle poles with web fabric straps.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of pole(s) and luminaire-lowering device(s) that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within a specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs from special warranty period.

1. Warranty Period: Five years from date of Substantial Completion.
2. Warranty Period for Corrosion Resistance: Five years from date of Substantial Completion.
3. Warranty Period for Color Retention: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design pole foundation and pole power system.

B. Seismic Performance: Foundation and pole shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event.
2. Component Importance Factor: 1.5 or 1.0.

C. Structural Characteristics: Comply with AASHTO LTS-6-M.

D. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied according to AASHTO LTS-6-M.

E. Live Load: Single load of 500 lbf distributed according to AASHTO LTS-6-M.

F. Ice Load: Load of 3 lbf/sq. ft., applied according to AASHTO LTS-6-M for applicable areas on the Ice Load Map.

G. Wind Load: Pressure of wind on pole and luminaire, calculated and applied according to AASHTO LTS-6-M.

1. Basic wind speed for calculating wind load for poles exceeding 50 feet in height is 100 mph, 90 mph.

a. Wind Importance Factor: 1.0.
b. Minimum Design Life: 50 years.
c. Velocity Conversion Factor: 1.0.

2. Basic wind speed for calculating wind load for poles 50 feet high or less is 100 mph, 90 mph.

a. Wind Importance Factor: 1.0.
b. Minimum Design Life: 25 years.
c. Velocity Conversion Factor: 1.0.

H. Strength Analysis: For each pole, multiply the actual EPA of luminaires and brackets by a factor of 1.1 to obtain the EPA to be used in pole selection strength analysis.

I. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

2.2 STEEL POLES

A. Source Limitations: Obtain poles from single manufacturer or producer.

B. Source Limitations: For poles, obtain each color, grade, finish, type, and variety of pole from single source with resources to provide products of consistent quality in appearance and physical properties.

C. Poles: Comply with ASTM A 500/A 500M, Grade B carbon steel with a minimum yield of 46,000 psig; one-piece construction up to 40 feet in height with access handhole in pole wall.

1. Shape: Square, straight.
2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

D. Poles: Comply with ASTM A 240/A 240M or ASTM A 666, stainless steel with a minimum yield of 55,000 psig ; one-piece construction up to 40 feet in height with access handhole in pole wall.

1. Shape: Square, straight.
2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

E. Steel Mast Arms: Single-arm type, continuously welded to pole attachment plate. Material and finish same as plate.

F. Brackets for Luminaires: Detachable, cantilever, without underbrace.

1. Adaptor fitting welded to pole, allowing the bracket to be bolted to the pole-mounted adapter, then bolted together with galvanized-steel bolts.
2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match pole material and finish.

G. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

H. Fasteners: Galvanized steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.

1. Materials: Compatible with poles and standards as well as the substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.
2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

I. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size indicated, and accessible through handhole.

J. Steps: Fixed steel, with nonslip treads.

1. For climbing positions, install at 15-inch vertical spacing, alternating on opposite sides of pole, oriented 180 degrees from each other; first step shall be at an elevation 10 feet above finished grade.
2. For working positions, install steps on opposite side of pole, oriented 180 degrees from each other at the same elevation.

K. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws.

L. Intermediate Handhole and Cable Support: Weatherproof, 3-by-5-inch handhole located at midpoint of pole, with cover for access to internal welded attachment lug for electric cable support grip.

M. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported load multiplied by a 5.0 safety factor.

N. Platform for Lamp and Ballast Servicing: Factory fabricated of steel, with finish matching that of pole.

O. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

P. Galvanized Finish: After fabrication, hot-dip galvanize according to ASTM A 123/A 123M.

Q. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces according to SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.

3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high gloss, high-build polyurethane enamel.

    a. Color: As selected by Architect.

R. Powder-Coat Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces according to SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair powder coat bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Powder Coat: Comply with AAMA 2604.

    a. Electrostatic-applied powder coating; single application and cured to a minimum 2.5- to 3.5-mils dry film thickness. Coat interior and exterior of pole for equal corrosion protection.
    b. Color: As selected by Architect.

2.3 POLE ACCESSORIES

A. Base Covers: Manufacturers' standard metal units, finished same as pole, and arranged to cover pole's mounting bolts and nuts.

2.4 MOUNTING HARDWARE

A. Anchor Bolts: Manufactured to ASTM F 1554, Grade 55, with a minimum yield strength of 55,000 psi.

1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C Mechanically deposited galvanization according to ASTM B 695, Class 50.
2. Headed rods
3. Threading: Uniform National Coarse or Uniform National 8, Class 2A.

B. Nuts: ASTM A 563, Grade A, Heavy-Hex

1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C Mechanically deposited galvanization according to ASTM B 695, Class 50.

2. Four nuts provided per anchor bolt, shipped with nuts pre-assembled to the anchor bolts.

C. Washers: ASTM F 436, Type 1.

1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C Mechanically deposited galvanization according to ASTM B 695, Class 50.
2. Two washers provided per anchor bolt.

2.5 GENERAL FINISH REQUIREMENTS

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine poles, luminaire-mounting devices, lowering devices, and pole accessories before installation. Components that are scratched, dented, marred, wet, moisture damaged, or visibly damaged are considered defective.

C. Examine roughing-in for foundation and conduit to verify actual locations of installation.

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

3.2 POLE FOUNDATION

A. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123 M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

B. Pre-Cast Foundations: Factory fabricated, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

C. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories.

1. Baseplate: Stamped with manufacturer's name, date of production, and cable entry.

D. Direct-Buried Foundations: Install to depth indicated on Drawings, but not less than as indicated. Add backfill in 6-inch to 9-inch layers, tamping each layer before adding the next, To ensure a plumb installation, continuously check pole orientation with plumb bob while tamping.

E. Direct-Buried Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height as indicated. To ensure a plumb installation, continuously check pole orientation with plumb bob while tamping.

1. Make holes 6 inches in diameter larger than pole diameter.
2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi at 28 days and finish in a dome above finished grade.
3. Use a short piece of 1/2-inch diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
4. Cure concrete a minimum of 72 hours before performing work on pole.

F. Anchor Bolts: Install plumb using manufacturer-supplied template, uniformly spaced.

3.3 POLE INSTALLATION

A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on drawing.

1. Fire Hydrants and Water Piping: 60 inches.
2. Water, Gas, Electric, Communications, and Sewer Lines: 10 feet.
3. Trees: 15 feet from tree trunk.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Section 033000 "Cast-in-Place Concrete."

D. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level according to pole manufacturer's written instructions.

1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
3. Install base covers unless otherwise indicated.
4. Use a short piece of 1/2 -inch diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Poles and Pole Foundations Set in Concrete-Paved Areas: Install poles with a minimum 6-inch wide, unpaved gap between the pole or pole foundation and the edge of the adjacent concrete slab. Fill unpaved ring with pea gravel. Insert material to a level 1 inch below top of concrete slab.

F. Raise and set pole using web fabric slings (not chain or cable) at locations indicated by manufacturer.

3.4 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum using insulating fittings or treatment.

B. Steel Conduits: Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch thick, pipe-wrapping plastic tape applied with a 50-percent overlap.

3.5 GROUNDING

A. Ground Metal Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole unless otherwise indicated.
2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground Nonmetallic Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole.
2. Install grounding conductor and conductor protector.
3. Ground metallic components of pole accessories and foundation.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Inspect poles for nicks, mars, dents, scratches, and other damage.
2. System function tests.

END OF SECTION 265613

SECTION 265619 - LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
2. Luminaire supports.
3. Luminaire-mounted photoelectric relays.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Section 265613 "Lighting Poles and Standards" for poles and standards used to support exterior lighting equipment.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaire.
4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.

5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project IES LM-79 OR IES LM-80.

    a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
    b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

6. Wiring diagrams for power, control, and signal wiring.
7. Photoelectric relays.
8. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Samples: For each luminaire and for each color and texture indicated with factory-applied finish.

D. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

E. Delegated-Design Submittal: For luminaire supports.

1. Include design calculations for luminaire supports and seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

A. 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. Luminaires.
2. Structural members to which luminaires will be attached.
3. Underground utilities and structures.
4. Existing underground utilities and structures.
5. Above-grade utilities and structures.
6. Existing above-grade utilities and structures.
7. Building features.
8. Vertical and horizontal information.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.

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

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Product Certificates: For each type of the following:

1. Luminaire.
2. Photoelectric relay.

E. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency

F. Source quality-control reports.

G. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
2. Glass, Acrylic, and Plastic Lenses, Covers, and Other Optical Parts: One for every 100of each type and rating installed. Furnish at least one of each type.
3. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products and complying with applicable IES testing standards.

C. Provide luminaires from a single manufacturer for each luminaire type.

D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

E. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

F. Mockups: For exterior luminaires, complete with power and control connections.

1. Obtain Architect's approval of luminaires in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.10 FIELD CONDITIONS

A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.

B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.11 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures, including luminaire support components.
b. Faulty operation of luminaires and accessories.
c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Period: 2 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

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

2.2 LUMINAIRE REQUIREMENTS

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

B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. UL Compliance: Comply with UL 1598 and listed for wet location.

E. Lamp base complying with ANSI C81.61 or IEC 60061-1.

F. Bulb shape complying with ANSI C79.1.

G. CRI of minimum 65 70 80 CCT of 2700 K,3000 K, 4100 K

H. L70 lamp life of 50,000 hours.

I. Lamps dimmable from 100 percent to 0 percent of maximum light output.

J. Internal driver.

K. Nominal Operating Voltage: 120 V ac.

L. In-line Fusing: On the primary for each luminaire.

M. Lamp Rating: Lamp marked for outdoor use and in enclosed locations.

N. Source Limitations: Obtain luminaires from single source from a single manufacturer.

O. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.3 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

A. Comply with UL 773 or UL 773A.

B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.

1. Relay with locking-type receptacle shall comply with ANSI C136.10.

2. Adjustable window slide for adjusting on-off set points.

2.4 LUMINAIRE TYPES

A. Area and Site:
1. Luminaire Shape: Round
2. Mounting: See Pole Mounted Luminaire Detail
3. Luminaire-Mounting Height: 20’.
4. Distribution: Type I, Type II, Type III, Type IV, Type V.
5. Diffusers and Globes: See lighting fixture schedule on drawings.
6. Housings:

a. Extruded-aluminum housing and heat sink.
b. powder-coat finish.

2.5 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Stainless steel. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

D. Diffusers and Globes:

1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

G. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
2. Provide filter/breather for enclosed luminaires.

H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

    a. "USE ONLY" and include specific lamp type.
    b. Lamp diameter, shape, size, wattage and coating.
    c. CCT and CRI for all luminaires.

2.6 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

C. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.

D. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

    a. Color: As selected from manufacturer's standard catalog of colors.

2.7 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.

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

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Install lamps in each luminaire.

D. Fasten luminaire to structural support.

E. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Support luminaires without causing deflection of finished surface.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

F. Wall-Mounted Luminaire Support:

1. Attached using through bolts and backing plates on either side of wall] <Insert means of attachment.

G. Wiring Method: Install cables in raceways. Conceal raceways and cables.

H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.

I. Coordinate layout and installation of luminaires with other construction.

J. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.3 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

A. Aim as indicated on Drawings.

B. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.4 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.6 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Verify operation of photoelectric controls.

C. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):

    a. IES LM-5.
    b. IES LM-50.
    c. IES LM-52.
    d. IES LM-64.
    e. IES LM-72.

2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

D. Luminaire will be considered defective if it does not pass tests and inspections.

E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.

3.8 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265619

SECTION 271100 - COMMUNICATION EQUIPMENT ROOMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Related Sections:

1. Division 271300 Section Communications Backbone Cabling.
2. Division 271500 Section Communications Horizontal Cabling

1.02 SUMMARY

A. Description

1. The scope of work required as part of this project shall include (1) new I/T Room. This area shall include floor 4-post server racks, ladder racking and wall mounted devices as indicated within the drawing details.

B. Section Includes:

1. Telecommunications Mounting Devices.
2. Telecommunications Pathways.

C. BICSI: Building Industry Consulting Service International

D. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel not exceeding 6 inches in width.

E. LAN: Local Area Network.

F. RCDD: Registered Communications Distribution Designer.

G. “Project Manager” shall mean the Owner’s appointed representative.

H. As Necessary” shall mean work which is required for completed construction, but is not necessarily shown or described in the Contract Documents.

I. “As Required” shall mean work which is required for completed construction and is shown on the drawings or described in the project specification.

J. “Install” shall mean to set in place complete with all mounting facilities and connections as required ready for normal use of service.

K. “Substantial Completion” shall mean that the project is sufficiently complete to be utilized for its intended use as stated in the body of this written specification.

L. “Conduit” shall include all fittings, sleeves, connections, hangers and other accessories related to such conduit.

M. “Surface Metal Raceway” shall include all fittings, sleeves, connections, hangers and other accessories related to such raceway.

N. “Concealed” shall mean hidden from sight, as in chases, furred spaces, shafts, fixed ceiling or embedded in construction.

O. “Exposed”, shall mean not “concealed” as defined above.

P. The words “Furnish”, “Supply” and “Provide” shall mean purchase, deliver to the job site, protect and provide interim storage and install in accordance with manufacturer’s specifications.

Q. Words “Approved Equal” shall mean any product which in the opinion of the Technology Consultant is equal in quality, arrangement, appearance, and performance to the product specified.

R. “Cabling” shall mean cable assembly, raceway, conductors, fittings and any other necessary accessories to make a complete wiring system.

S. “Product” shall mean any item of equipment, material, fixture, apparatus, appliance or accessory installed under this Division.

T. Words in the singular shall also mean and include the plural, wherever the context so indicates, and words in the plural shall mean the singular, wherever the context so indicates.

U. “Contractor” refers to the biding/installation Contractor responsible for furnishing and installation of all work indicated within this specification.

1.03 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Floor-mounted equipment racks and cabinets and cable pathways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

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

1.04 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: As-built drawings for communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

C. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

D. Seismic Qualification Certificates: For floor-mounted racks, cabinets, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions. Base certification on the maximum number of components capable of being mounted in each rack type. Identify components on which certification is based.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.05 QUALITY ASSURANCE

A. Installation of products shall be performed in accordance with the Manufacturer's suggested Installation procedures.

B. Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings shall be under the direct supervision of RCDD/NTS and/or Commercial Installer, Level 2.
2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician and/or Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
3. Field Inspector: Currently registered by BICSI as RCDD and/or Commercial Installer, Level 2 to perform the on-site inspection.

C. Telecommunications Pathways and Spaces shall comply with TIA-569-C.

D. Grounding shall comply with ANSI-J-STD-607-A.

1.06 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install equipment racks, cabinets, frames or cable trays until spaces are enclosed, built-out and weather-tight, wet work in spaces is complete and dry, and work above ceilings is complete.

1.07 COORDINATION

A. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier/ Service Providers.

1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
2. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of the Voice equipment, LAN equipment, Security Equipment, and all other systems that share space within the Telecommunication Equipment rooms.

B. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

PART 2 - PRODUCTS

2.01 PATHWAYS

A. General Requirements: Comply with TIA-569-C.

B. Riser and distribution cables leaving the room to building TRs should be via cable tray, four-inch (4") conduits or sleeved cores.

C. The exact number of conduits required or size of the cable wireway should be determined based upon the amount of fiber and copper cable that must be supported in each closet and each computer or communications room.

D. Additional conduits or sleeved cores must be included in the design to provide for future growth.

E. All conduits/coring should be kept six inches (6") or less from walls whenever construction permits.

F. Cable Support: Cable support brackets shall be designed to prevent degradation of cable performance and pinch points that could damage cable. Cable tie slots fasten cable ties to brackets.

1. Comply with NFPA 70 and UL 2043 for fire-resistant and low-smoke-producing characteristics.
2. Support brackets with cable tie slots for fastening cable ties to brackets.
3. Lacing bars, spools, J-hooks, and D-rings.
4. Straps and other devices.

G. Conduit and Boxes: are not within part of this section and shall be described within other sections of this bid document.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with NECA 1.

B. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.

C. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.02 FIRESTOPPING

A. Comply with requirements in Division 07 Section "Penetration Firestopping."Comply with TIA-569-C.

B. All conduits etc., passing through fire rated floors, walls and partitions, shall have the space between the raceways, sleeves and all penetrations filled with a reusable fire stopping material such as Firestop Putty, Adhesive Firestop Sealant or Firestop Compound as manufactured by STI or approved equal.

3.03 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements in Division 26 Section "Identification for Electrical Systems." Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

B. See Division 27 Section "Communications Horizontal Cabling" for additional identification requirements. See Evaluations for discussion of TIA/EIA standard as it applies to this Section. Paint and label colors for equipment identification shall comply with TIA-606-B for Class 2, Class 3, or Class 4 level of administration including optional identification requirements of this standard.

C. Labels shall be preprinted or computer-printed type.

END OF SECTION 271100

SECTION 271300 - COMMUNICATIONS BACKBONE CABLING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Related Sections:

1. Division 271100 Section "Communications Equipment Room Fittings".

1.02 SUMMARY

A. Section Includes:

1. Pathways.
2. UTP cable.
3. Multi-Mode: OM3, 50/125 micrometer, 24 strand, armored optical fiber cabling.
4. Single mode optical fiber cabling, 24 strand, armored optical fiber cabling.
5. Cable connecting hardware, patch panels, and cross-connects.
6. Cabling identification products.
7. Testing procedures.

1.03 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

C. EMI: Electromagnetic interference.

D. IDC: Insulation displacement connector.

E. LAN: Local area network.

F. RCDD: Registered Communications Distribution Designer.

G. UTP: Unshielded twisted pair.

1.04 BACKBONE CABLING DESCRIPTION

A. Backbone cabling system shall provide interconnections between Tele-communications equipment rooms, main terminal spaces and entrance facility rooms for the voice/data cabling systems.

B. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patching or jumpers used for backbone-to-backbone cross-connection to service provider equipment.

C. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

1.05 PERFORMANCE REQUIREMENTS

A. General Performance: Backbone cabling system shall comply with transmission standards in TIA-568-C.2 and TIA-568-C.3, when tested according to test procedures of this standard.

1.06 SUBMITTALS

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

1. For coaxial cable, include the following installation data for each type used:

a. Nominal OD.
b. Minimum bending radius.
c. Maximum pulling tension.

B. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. Cabling administration drawings and printouts.
3. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
4. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:

a. Vertical and horizontal offsets and transitions.
b. Clearances for access above and to side of cable trays.
c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

C. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

D. Source quality-control reports.

E. Field quality-control reports.

F. Maintenance Data: For splices and connectors to include in maintenance manuals.

G. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.07 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings and field testing program development by an RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Testing Agency Qualifications: An NRTL.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

C. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

D. 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.

E. Telecommunications Pathways and Spaces: Comply with TIA-569-C.

F. Grounding: Comply with ANSI-J-STD-607-A.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical loss test set.
2. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.
3. Test each pair of UTP cable for open and short circuits.

1.09 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.10 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.01 PATHWAYS

A. General Requirements: Comply with TIA-569-C.

B. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.

1. Support brackets with cable tie slots for fastening cable ties to brackets.
2. Lacing bars, spools, J-hooks, and D-rings.
3. Straps and other devices.

C. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems." Flexible metal conduit shall not be used.

1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.

2.02 UTP CABLE

A. Description: Voice Backbone Cabling.

B. Cable shall be 100-ohm, 100 -pair UTP, formed into 25-pair binder groups, plenum rated cable.

1. Comply with ICEA S-90-661 for mechanical properties.
2. Comply with TIA-568-C.2 for performance specifications.
3. Comply with TIA-568-C.2, Category 5E.

C. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include and are limited to the following:

1. Berk-Tek
2. Superior Essex
3. Belden

2.03 UTP CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include and are limited to the following:

1. Leviton
2. Hubbell Premise Wiring
3. Belen

B. General Requirements for Cable Connecting Hardware: Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

C. Connecting Blocks: 110-style IDC for Category 5E. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

D. 100 Pair 110 Style CAT 5E 19” rack mounted patch panels to allow for cross-connection from voice origination (PBX) to workstations via CAT 5E patch cords.

E. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

1. Number of Terminals per Field: One for each conductor in assigned cables.

F. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.

1. Number of Jacks per Field: One for each four-pair UTP cable indicated, plus spares and blank positions adequate to suit specified expansion criteria.

G. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.

2.04 IDENTIFICATION PRODUCTS

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including Etching, label stocks, laminating adhesives, and inks used by label printers.

B. Labeling of all cable is described within the drawing documents.

2.05 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test cables on reels according to TIA-568-C.2.

C. Factory test UTP cables according to TIA-568-C.2.

D. Factory test multimode optical fiber cables according to TIA-526-14-A and TIA-568-C.3.

E. Cable will be considered defective if it does not pass tests and inspections.

F. Each Fiber Optic Termination Panel shall be clearly labeled indicating (1) the destination(s) of the cable(s) and (2) fiber number of each fiber position. The cable identifiers are to be secured to (1) the side and (2) the front cover of the panel enclosure.

G. Prepare test and inspection reports.

PART 3 - EXECUTION

3.01 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.02 WIRING METHODS

A. Wiring Method: Install cables in raceways and J-hooks except where cable trays are required in Drawings. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway and Boxes for Electrical Systems."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

D. Pre-terminated fiber optic cabling will be accepted. Manufacture shall be approved upon product submission.

3.03 INSTALLATION OF PATHWAYS

A. Cable Trays: Comply with NEMA VE 2 and TIA-569-C.

B. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27 Section "Communications Equipment Room Fittings." Drawings indicate general arrangement of pathways and fittings.

C. Comply with TIA-569-C for pull-box sizing and length of conduit and number of bends between pull points.

D. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.

E. Install manufactured conduit sweeps and long-radius elbows whenever possible.

F. Pathway Installation in Communications Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard when entering room from overhead.
4. Extend conduits 3 inches above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.04 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA-568-C.2.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."

3. Install 110-style IDC termination hardware unless otherwise indicated.
4. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
10. In the communications equipment room, install a 10-foot long service loop on each end of cable.
11. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:

1. Comply with TIA-568-C.2.
2. Do not untwist UTP cables more than ½ inch from the point of termination to maintain cable geometry.

3.05 FIRESTOPPING

A. Comply with requirements in Division 07 Section "Penetration Firestopping."Comply with TIA-569-C.

B. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.06 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI-J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.07 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

1. Administration Class: 2.
2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

C. Clearly label all Data Patch Panels via etching, as indicating the Telecommunication Room Number, The Data Patch Panel letter designation and the Data Port Number on the Data Patch Panel Ports 1 through 48. Each Telecommunication Room shall start with Data Patch Panel ‘A’ and continue through the Alphabet.

D. See Division 27 Section "Communications Horizontal Cabling" for additional identification requirements. See Evaluations for discussion about TIA standard as it applies to this Section. Paint and label colors for equipment identification shall comply with TIA-606-B for Class 2 level of administration including optional identification requirements of this standard.

E. Comply with requirements in Division 27 Section "Communications Horizontal Cabling" for cable and asset management software.

F. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

G. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

H. Cable and Wire Identification:

1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

    a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
    b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
6. All fiber optic backbone and copper (inter-building, riser and tie) cables shall be identified AT BOTH ENDS with a designation that identifies where the opposite end of the same

cable terminates (e.g. Equipment Room or Telecommunications Room I.D.). In addition, labeling of all fiber optic cables shall include the number of fibers in the cable.

7. Each fiber optic termination panel shall be clearly labeled indicating the destination of the cable(s) and the fiber number of each fiber position. The cable identifiers are to be secured to (1) the side and (2) the front cover of the panel enclosure.

I. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA-606-B, for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.08 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Visually inspect UTP and optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.2.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

END OF SECTION 271300

SECTION 271500 - COMMUNICATIONS HORIZONTAL CABLING

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. UTP cabling.
2. Cable connecting hardware, patch panels, and cross-connects.
3. Telecommunications outlet/connectors.
4. Cabling system identification products.
5. Cable management system.

1.3 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.

C. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

D. EMI: Electromagnetic interference.

E. IDC: Insulation displacement connector.

F. LAN: Local area network.

G. MUTOA: Multiuser telecommunications outlet assembly, a grouping in one location of several telecommunications outlet/connectors.

H. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.

I. RCDD: Registered Communications Distribution Designer.

J. UTP: Unshielded twisted pair.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordinate layout and installation of telecommunications cabling with Owner's telecommunications and LAN equipment and service suppliers.

B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

1.5 ACTION SUBMITTALS

A. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration drawings and printouts.
4. Wiring diagrams to show typical wiring schematics, including the following:

   a. Cross-connects.
   b. Patch panels.
   c. Patch cords.

5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For splices and connectors to include in maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings by an RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Testing Agency Qualifications: An NRTL.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test each pair of UTP cable for open and short circuits.

PART 2 - PRODUCTS

2.1 HORIZONTAL CABLING DESCRIPTION

A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called a "permanent link," a term that is used in the testing protocols.

1. TIA/EIA-568-B.1 requires that a minimum of two (2) telecommunications outlet/connectors be installed for each work area.
2. Horizontal cabling shall contain no more than one (1) transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
3. Bridged taps and splices shall not be installed in the horizontal cabling.
4. Splitters shall not be installed as part of the optical fiber cabling.

B. A work area is approximately 100 sq. ft., and includes the components that extend from the telecommunications outlet/connectors to the station equipment.

C. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment or in the horizontal cross-connect.

2.2 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA/EIA-568-B.1 when tested according to test procedures of this standard.

B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

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

D. Grounding: Comply with J-STD-607-A.

2.3 UTP CABLE HARDWARE

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one (1) of the following:

1. ADC
2. American Technology Systems Industries, Inc.
3. Belden Inc.
4. Dynacom Inc.

5. Hubbell Premise Wiring
6. Leviton Commercial Networks Division
7. Molex Premise Networks; a division of Molex, Inc.
8. Panduit Corp.
9. Siemon Co. (The)
10. Tyco Electronics Corporation; AMP Products

B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

C. Connecting Blocks: 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus twenty-five percent (25%) spare. Integral with connector bodies, including plugs and jacks where indicated.

D. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

1. Number of Terminals per Field: One (1) for each conductor in assigned cables.

E. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.

1. Number of Jacks per Field: One (1) for each four-pair UTP cable indicated.

F. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.

G. Patch Cords: Factory-made, four-pair cables in 36-inch lengths; terminated with eight-position modular plug at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification.

2.4 IDENTIFICATION PRODUCTS

A. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

B. Comply with requirements in Section 260553 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test UTP cables on reels according to TIA/EIA-568-B.1.

C. Factory test UTP cables according to TIA/EIA-568-B.2.

D. Cable will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WIRING METHODS

A. Install cables in pathways and cable trays except within consoles, cabinets, desks, and counters except in accessible ceiling spaces and partitions where unenclosed wiring method may be used. Conceal pathways and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.

B. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures:

1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
2. Install lacing bars and distribution spools.
3. Install conductors parallel with or at right angles to sides and back of enclosure.

3.2 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA/EIA-568-B.1.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. MUTOA shall not be used as a cross-connect point.
5. Consolidation points may be used only for making a direct connection to telecommunications outlet/connectors:

a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
b. Locate consolidation points for UTP at least 49 feet from communications equipment room.

6. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
7. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
8. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
9. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
10. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
11. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
12. In the communications equipment room, install a 10-foot long service loop on each end of cable.

13. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:

1. Comply with TIA/EIA-568-B.2.
2. Do not untwist UTP cables more than ½ inch from the point of termination to maintain cable geometry.

D. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

E. Group connecting hardware for cables into separate logical fields.

3.3 FIRESTOPPING

A. Comply with TIA-569-B, Annex A, "Firestopping."

B. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.4 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.5 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.

B. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.

C. Comply with requirements in Section 099123 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

D. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration.

E. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

F. Cable and Wire Identification:

1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

    a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
    b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in I/T Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
6. Uniquely identify and label work area cables extending from the MUTOA to the work area. These cables may not exceed the length stated on the MUTOA label.

G. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA-606-A.

1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.6 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Visually inspect UTP cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
2. Visually confirm Category 6**,** marking of outlets, cover plates, outlet/connectors, and patch panels
3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
4. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

5. UTP Performance Tests:

a. Test for each outlet and MUTOA. Perform the following tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.2:

1) Wire map.
2) Length (physical vs. electrical, and length requirements).
3) Insertion loss.
4) Near-end crosstalk (NEXT) loss.
5) Power sum near-end crosstalk (PSNEXT) loss.
6) Equal-level far-end crosstalk (ELFEXT).
7) Power sum equal-level far-end crosstalk (PSELFEXT).
8) Return loss.
9) Propagation delay.
10) Delay skew.

6. Final Verification Tests: Perform verification tests for UTP systems after the complete communications cabling and workstation outlet/connectors are installed.

a. Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
b. Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

B. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

C. End-to-end cabling will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 271500

SECTION 311000 - SITE CLEARIING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This section specifies requirements for site clearance and structure demolition.

B. The Work includes, but is not limited to, the following:

1. Protection of existing improvements and vegetation to remain.
2. Clearing and grubbing.
3. Demolition and the removal of structures, retaining walls, signage, light standards, foundations, curbing, and appurtenances.
4. Demolition and removal of pavements, concrete, asphalt, and pavers.
5. Removal and/or abandonment of utilities.
6. Filling or removal of underground tanks, structures, and piping.
7. Disposal of material from clearing, grubbing, thinning, and demolition in approved off-site disposal areas.
8. Filling of voids and excavations resulting from demolition.
9. Removal and stockpiling of topsoil.
10. Construction fence.
11. Tree protection.

C. This Work shall also include the preservation from injury or defacement of all vegetation and objects designated to remain, as shown on the Drawings, or as directed by the Owner's representative.

D. Related Sections

1. Other specification sections, which directly relate to the work of this Section, include:

a. Section 311500 "Erosion and Sedimentation Control"
b. Section 312000 "Earth Moving"
c. Section 329200 "Turf and Grasses"

1.3 LAWS AND REGULATIONS

A. Conform to applicable codes for the safety of adjacent structures and utilities, dust control, and runoff control.

B. Obtain required permits and licenses from governing authorities. Pay the associated permit fees, including disposal charges.

C. Notify affected utility companies before starting work and comply with their requirements. Notify "Call Before You Dig" by telephone at 1-800-922-4455 at least 48 hours prior to construction.

D. Do not close or obstruct roadways, sidewalks, or hydrants without permits.

E. Conform to applicable state and local regulatory procedures if hazardous or contaminated materials are discovered.

1.4 ENVIRONMENTAL REQUIREMENTS

A. Construct temporary erosion control systems as required or as directed by the Town's representative to protect adjacent properties and street storm drains from sedimentation due to erosion.

1.5 SITE CONDITIONS

A. Site conditions existing during the bidding period will be maintained by the Owner, insofar as practical.

B. The Contractor shall have a clear understanding of existing conditions of the site before submitting his/her bid and shall be fully responsible for carrying out all site work required to fully and properly execute the work of the Contractor, regardless of the conditions encountered in the actual work.

C. Actual site condition variations that differ from those of the bidding period that affect site preparation operations shall be brought to the attention of the Owner's representative prior to the commencement of any site work.

1.6 SUBMITTALS

A. The Contractor shall submit the following information to the Engineer of record for review and approval before commencing any site work:

1. Permits and notices authorizing demolition.
2. Certificates of utility service severances.
3. Permits for transport and disposal of debris.
4. Demolition procedures and operational sequence.

PART 2 - PRODUCTS

2.1 TREE PROTECTION FENCING

A. Tree protection fencing shall be wire bound, wood-roll snow fence, 4 feet high (minimum) with 3/8-inch by 1½-inch wide pickets, spaced approximately 2 inches apart and bound together with 13-gauge (minimum) galvanized steel wire, or equivalent plastic construction fencing. Stakes shall be a minimum 2-inch x 2-inch x 6-foot wooden stakes or steel posts driven a minimum of 1.5 feet into the ground. Stakes/posts shall be spaced a maximum of 8-feet on center.

2.2 CHAIN LINK CONSTRUCTION FENCE

A. Temporary chain link construction fencing shall conform to Article M.10.05 of Form 816, unless otherwise detailed or authorized by the Owner's representative.

PART 3 - EXECUTION

3.1 PROTECTION

A. The Contractor shall flag the limits of clearing shown on the Drawings by accurate field survey with marked stakes or other means acceptable to the Owner's representative. The Owner's representative shall be notified a minimum of five (5) working days prior to scheduled commencement of clearing operations to review the flagged limits. Adjust the clearing limits as directed by the Owner's representative.

B. Before clearing begins, protect any trees designated to remain with tree protection fencing to the approximate diameter of foliage to prevent damage to the trunk, foliage, and root system by construction equipment and procedures.

C. Place tree protection fencing as required to protect other plants, monuments, existing improvements, and adjacent property areas to remain uncleared from damage.

D. The Contractor shall repair immediately any damage to existing trees or root systems that are to remain. The Contractor shall employ an arborist licensed in the state of Connecticut to determine the repair needs and methods for approval by the Owner's representative. Should the arborist determine repair is not possible, the Contractor will be required to replace the damaged tree with the same size and species tree, as directed.

E. The Contractor shall be responsible for replacing trees with new trees of equivalent total quality and type should existing trees to remain be damaged.

F. The tree protection fencing shall be maintained for the duration of construction operations. The work shall include immediate replacement of any damaged fence.

3.2 TREE PROTECTION FENCING

A. Install fencing completely around all trees to be protected within the project area as shown on the Drawings or as directed by the Owner's representative. Install fencing before any construction activities commence and maintain in place until final grading and seeding is complete and accepted.

B. The Contractor shall not place or stockpile any construction or excavation materials within the drip line of any trees. Vehicle and construction equipment are not to be parked, nor left running (idling), within the drip line of any tree.

C. Any excavation within the drip line of trees to be protected shall be performed by hand, unless otherwise directed by the Owner and or Landscape Architect or Engineer of record.

D. Where construction equipment must pass within the drip line of trees to remain, the Contractor shall install wooden tree protection on the trunk of the tree, as detailed, and as directed by the Owner's representative.

E. Where excavation requires the cutting of tree roots, roots shall be cut with sharp cutting tools and reburied as soon as possible. Until roots can be reburied, the exposed roots are to be covered with wet burlap to prevent roots from drying out. The burlap is to be kept wet until the roots can be reburied.

F. Where cutting of tree root system has occurred, the Contractor shall water the tree root system to the extent of the tree canopy with at least ½-inch of water within 72 hours of when the damage occurred.

G. When less than ½-inch of water has fallen during a 7-day period, the Contractor shall water the tree root system to the extent of the tree canopy with at least ½-inch of water.

H. Trees damaged by construction activities are to be repaired within 72 hours using current arboricultural standards. Those trees determined by the Owner's representative to be damaged beyond repair shall be removed and replaced by the Contractor at no additional cost to the Owner.

3.3 UTILITIES

A. Notify all corporations, companies, individuals, or local authorities owning, or having jurisdiction over, utilities running to, through, or across areas to be affected by clearing and demolition operations.

B. Locate and identify existing utilities that are to remain and protect them from damage.

C. Have all utility services, designated as abandoned or to be removed, disconnected in accordance with the requirements of the utility owner.

3.4 CLEARING AND GRUBBING

A. Clearing shall include cutting, removal, and off-site disposal of trees, bushes, shrubs, stumps, fallen timber, refuse, trash, fencing, and other incidental materials not required for reuse on the site.

B. The Contractor shall grub the area within the clearing limits to completely remove stumps and root systems.

C. Depressions, excavations, and voids resulting from the removal of stumps or roots shall be filled with suitable material and compacted as specified in Section 312000 "Earth Moving".

D. Topsoil shall be stripped to its full depth and stockpiled in the locations shown on the Drawings, or as directed by the Owner's representative. All surplus topsoil shall be removed from the property. Topsoil shall not be mixed with subsoils or other debris.

E. All stockpiles shall be surrounded by a row of hay bales or silt fence and/or completely covered by a tarp and securely anchored. Stockpiles that will not be used within thirty (30) days shall be seeded to vegetate the piles.

3.5 SELECTIVE CLEARING AND THINNING

A. Selective clearing and thinning shall be completed as directed by the Owner's representative. Approximate limits of selective clearing and thinning are shown on the Drawings.

B. The work shall include the removal of dead and diseased tree limbs and plants and pruning and removal of live vegetation that interferes with the growth of other trees and plants. Areas of dense growth shall be thinned to provide room for healthy growth.

3.6 DEMOLITION REQUIREMENTS

A. Conduct demolition operations in a manner that will prevent damage to adjacent structures, utilities, pavements, and other facilities to remain.

B. Cease operations immediately if any damage, settlement, or other adverse effect on adjacent structures occurs. Immediately notify the Owner's representative and regulatory authorities. Do

not resume operations until conditions are corrected, damage repaired, and approval has been received from the Owner.

C. Obtain written permission from adjacent property owners when demolition equipment will traverse, infringe upon, or affect access to their property. Copies of the permission documents shall be submitted to the Owner and the Landscape Architect or Engineer of record.

D. Provide hoses and water connections. Spray water on any demolition debris to minimize dust.

3.7 FILLING VOIDS

A. Completely fill excavation areas and voids resulting from demolition or removal of structures including utilities, underground fuel storage tanks, wells, and cisterns with suitable material as specified in Section 312000 “Earth Moving”.

B. Areas to be filled shall be free of standing water, frost, frozen, and unsuitable material prior to fill placement.

C. Place and compact fill materials in conformance with the requirements as specified in Section 312000 “Earth Moving”. Fill shall be placed in horizontal layers not exceeding 8 inches in loose depth.

D. Grade filled area surface to match adjacent grades and slope to provide surface drainage.

3.8 REMOVAL AND ABANDONMENT OF UTILITIES

A. All existing structures, utilities, and appurtenances of any kind shall be completely removed within the limits of excavation for the new building.

B. All abandoned utilities and utility structures greater than 8 inches in diameter located at least 4 feet below bottom of finished grade shall be sealed with concrete slurry or brick masonry at the limit of excavation. All utilities shall be entirely removed if they are within 4 feet of finished grade.

C. Manholes and catch basins designated to be abandoned shall have all lines plugged with brick and mortar prior to filling with sand or gravel. The top 4 feet of these structures shall be removed, and the bottom slab broken up prior to filling.

D. The Contractor shall remove frames, covers, and grates from manholes, catch basins, and gate valves and satisfactorily store and protect them until they are required for reuse in the work. Existing frames, covers, and grates judged to be unsuitable for reuse shall be removed from the site and disposed of by the Contractor.

3.9 DISPOSAL OF DEBRIS

A. Remove from the site all materials resulting from demolition operations and all debris resulting from clearing and grubbing operations.

B. No burning of any material will be allowed.

END OF SECTION 311000

SECTION 311500 EROSION AND SEDIMENT CONTROL

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and other Division 1 Specification Sections, apply to this Section.

1.2 DESCRIPTION OF WORK

A. Providing all temporary erosion control measures shown on the Drawings and required by the Owner's representative during the life of the Construction Contract to control soil erosion and water pollution.

B. The installation and maintenance of silt fence, hay bales, temporary diversion swales, temporary sedimentation traps and basins, construction entrances, fiber mats, catch basin filters, straw, netting, gravel, trenches, mulches, grasses, slope drains and other approved erosion control devices or methods.

C. Erosion control shall conform to the 2002 Connecticut Soil Erosion and Sedimentation Control Guidelines.

1.3 RELATED SECTIONS

A. Sections, which directly relate to the work of this Section, include:

1. Section 311000 - Site Clearing
2. Section 312000 – Earthmoving
3. Section 329219 – Seeding

1.4 REFERENCES

A. 2002 Connecticut Guidelines for Soil Erosion and Sediment Control, May 2002.

1.5 COORDINATION WITH PERMANENT EROSION CONTROL PROVISIONS

A. The temporary control provisions shall be coordinated with the permanent site stabilization to the extent practical to ensure economical, effective and continuous erosion control throughout the construction and post-construction period.

1.6 LAWS AND REGULATIONS

A. The DEEP General Permit for Discharge of Stormwater and Dewatering Wastewaters from Construction Activities (General Permit) (if applicable) and all other local, state and federal requirements.

1.7 PRIOR TO CONSTRUCTION

A. Prior to the start of the construction, the Contractor shall submit to the Owner's representative their schedule for the construction of required temporary and permanent erosion and sedimentation control measures, clearing and grubbing, grading, construction, and paving. No work shall be started until erosion control schedules and methods of operations have been accepted by the Owner's representative.

1.8 CONSTRUCTION OPERATIONS

A. When it becomes necessary, the Owner's representative will inform the contractor of construction procedures and operations that jeopardize erosion control provisions. If these construction procedures and operations are not corrected promptly, the Owner's representative may suspend the performance of any or all construction until corrections have been made, and such suspension shall not be the basis of any claim by the Contractor for additional compensation from the Owner for an extension of time to complete the Work.

1.9 CONSTRUCTION REQUIREMENTS—TEMPORARY SEDIMENT CONTROL

A. The Owner's representative has the authority to order immediate, additional, temporary control measures to prevent contamination of adjacent streams or other watercourses, or other areas of water impoundment and damage by erosion. These additional measures may be ordered based upon the visual observation of the Owner's representative .

B. The Contractor shall construct all permanent erosion and sediment control features at the earliest practical time as outlined in the accepted schedule. Temporary erosion and sediment control measures shall be used to correct conditions that develop during construction, which were unforeseen, but are needed prior to installation of permanent control features, or that are needed temporarily to control erosion or sedimentation which develops during construction operations.

C. Where erosion is likely to be a problem, clearing and grubbing operations shall be scheduled and performed so that grading operations and permanent erosion and sediment control features can follow immediately thereafter, if conditions permit; otherwise, temporary control measures will be required between successive construction stages.

D. Failure by the Contractor to control erosion, pollution, and siltation shall be cause for the Owner's representative to employ outside assistance to provide the necessary corrective measures. The cost of such assistance, including engineering costs, will be charged to the Contractor and appropriate deductions made to the Contractor's monthly progress payment request.

E. The Contractor shall periodically remove sediment from erosion control facilities. The accumulated sediment shall not be allowed to rise above the mid height of the erosion control facilities. The Contractor shall modify and improve erosion control facilities and replace deteriorated hay bales and other devices as required by the Owner's representative.

F. Temporary and permanent erosion and sedimentation control measures are shown on the Drawings. The Contractor shall strictly adhere to the proposed measures. Additionally, temporary measures shall be constructed to accommodate field conditions that develop during construction.

1.10 MAINTENANCE OF EROSION CONTROL MEASURES

A. The Contractor shall check the condition of erosion control devices daily and maintain them in good operating condition. Hay bales shall be replaced when deteriorated, and when required by the Owner's representative.

B. The Contractor shall inspect the condition of diversion swales, biofiltration swales, sediment traps, detention basins and other erosion and sedimentation control devices

after each storm event >0.5 inches. Repairs shall be made as necessary and as required by the Owner's representative.

C. Accumulated sediment trapped by erosion and sedimentation control devices shall be removed as required by the SWPCP.

D. Temporary soil erosion and sedimentation control devices shall be removed and adjacent areas outside the limits of grading restored upon completion of the work, or when required by the Owner's representative.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Seed for quick growing grasses, wheat, rye or oats shall be selected based on site and seasonal conditions from Figure TS-2 of the 2002 Connecticut Guidelines for Soil Erosion and Sediment Control, May 2002.

B. Erosion Control Blanket/Fabric Netting shall be:

- Curlex blankets, as manufactured by American Excelsior Company, or
- Polyjute Style 465 GT, as manufactured by Synthetic Industries, or
- Tensar Erosion Mat, as manufactured by the Tensar Corporation, or approved equivalent.

C. Hay bale for sediment traps, consisting of hay bales banded with wire or nylon tape (minimum two bands for bale), shall be approximately two-feet, six-inches in length.

D. Stakes for hay bales shall be standard 1/2-inch x 3-foot reinforcing steel rods, steel pickets, 1 inch x 1 inch x 3-foot wood stakes or approved equivalent.

E. Silt fence fabric shall be Mirafi 100X, Geotex 915SC, Contech C200, or approved equivalent.

F. Filter fabric at a construction entrance shall Mirafi 600X, Geotex 200ST, Contech C-60NW, or approved equal.

G. Catch basin filters shall be Siltsack by ACF Environmental, Dandy Sack by Dandy Products, Silt Mat by Kristar, or approved equal.

PART 3—EXECUTION

3.1 EROSION CONTROL - HAY BALES

A. Hay bales shall be installed in accordance with the details indicated on the drawings and at the following locations, as required by the Owner's representative and as shown on the Drawings:

1. Toe of slope of embankment construction to filter all runoff flowing to off-site discharges.

2. Toe of temporary earthwork stockpile slopes.

3. Across a construction ditch prior to entry into drainage system or waterway.

4. Each side of completed drainage inlets.

5. Dewatering Pumping Settling Basins.

6. Other locations shown on the Contract Drawings or designated by the Owner's representative.

B. Tightly abut hay bales to form a continuous barrier. Secure bales in place with two stakes per bale. The bales shall be trenched 4 inches into the ground. Soil shall be placed on the upside slope side of the bales. Deteriorated, destroyed or rotted bales shall be replaced immediately. Sediment shall be removed and disposed of periodically from behind the hay bales. The accumulated sediment shall not be allowed to rise above the mid height of the bale. All sediment, hay bales and appurtenances shall be removed and disposed of at the completion of the Contract unless directed otherwise by the Owner's representative.

3.2 TEMPORARY EROSION CONTROL MATS

A. Erosion control mats shall be installed in accordance with the manufacturer's recommendations.

B. All areas shall be smooth graded and compacted. Remove all rocks, dirt clods, vegetation and other obstructions that may cause damage to the mats.

C. Unroll mats parallel to the direction of water flow and lay flat against the ground. Overlap roll ends 1-2 feet with upslope mat on the top to prevent uplift of mat end by water flow. Overlay adjacent edges of mat by six inches. Extend mat 2-3 feet above the crest of steep slopes and anchor by excavating a 6-inch deep trench, and secure end of mat in trench, backfill and compact. Secure mat to the ground using staples or pins furnished by manufacturer of mat.

3.3 SILT FENCE

A. Silt fence shall be installed as shown on the Drawings.

B. Supporting posts shall be spaced a maximum of 5 feet on center, and driven at least one foot into the ground. Posts shall be 1-1/2-inch square or heavier wood posts, or standard steel posts.

C. Fabric shall be anchored in a 6-inch deep trench dug on the upslope side of the posts. The trench shall be at least 6 inches wide. The fabric shall be laid in the trench, backfilled and compacted.

D. Fabric rolls shall be spliced at posts. The fabric shall be overlapped 6 inches, folded over and securely fastened to posts.

E. Silt fences shall be inspected immediately after each storm event and at least daily during prolonged rainfall >0.5 inches.

3.4 CATCH BASIN FILTER

A. A catch basin sediment filter shall be installed in each existing catch basin as long as it remains in use. Filters shall be changed/cleaned per the manufacturer's recommendations, or as directed by the Owner's representative, during construction.
B. New catch basins shall have a filter installed immediately upon completion of construction. In addition, a hay bale, or similar, barrier shall be installed around the new basin and maintained in place until binder is placed or disturbed areas draining to it are stabilized.

END OF SECTION 311500

SECTION 312000 - EARTHMOVING

PART 1 - GENERAL

1.1 WORK INCLUDES

A. Excavation and disposal of unsuitable or excess materials.
B. Excavation, fill, backfill and refill, as indicated or required, including compaction.
C. Rock removal, as required.
D. Rough grading, including compaction of existing materials and granular fills, backfills, and refills.
E. Trench excavation, bedding and backfill for all utilities, as directed, including compaction.
F. Riprap and riprap bedding.
G. Installation, maintenance & removal of erosion control measures.

1.2 RELATED SECTIONS

A. Carefully examine all of the Contract Documents for requirements, which affect the Work in this Section. Other specification Sections, which directly relate to the Work of this Section include, but are not limited to, the following:

1. Section 311590 – Erosion Controls
3. Section 334100 - Storm Drainage Systems

1.3 BUILDING AREA

A. The area within limits of a minimum of five (5) feet or to such greater dimensions as indicated on the drawings outside the exterior face of the building is herein defined as the building area. All requirements for structure excavation and for fills and refills within the building area shall extend to these lines.

1.4 PROTECTION

A. Excavation Support: The work is to some extent located in an area near existing construction and new work. Operations will be conducted so as to provide adequate support at all times for these facilities. All excavation shall be sheeted, shored and braced. Excavation shall be sloped, if necessary, to prevent cave-ins, or undermining of these facilities. Sheeting, shoring and bracing shall be removed before backfilling is complete.

B. Dewater when excavations are to some extent below existing groundwater levels and the site is subject to surface water and groundwater flow during the course of construction.

1. Control and pitch the grading to prevent water from running into the excavated areas or to prevent damage to other structures or work already accomplished.

2. The Contractor shall furnish all pumping and other dewatering equipment necessary to keep excavated area dry during construction. The groundwater shall be pumped adequately so that the water table is maintained a minimum of

two (2) feet below the bottom of the excavation at all times. Filters shall be used on the dewatering devices to prevent the removal of fines from the soil. Water shall not be conducted onto adjacent property except in existing water courses.

3. Operations and Performance: Operate the dewatering system continuously, 24 hours per day, 7 days per week, until such time as construction work below existing water levels is complete, unless directed otherwise. Measure and record the performance of the dewatering system at the same time each day by use of suitable observation wells or piezometers installed in conjunction with the dewatering system. After placement of initial slabs and backfill, the water level may be allowed to rise, but at no time allow it to be higher than one foot below the prevailing level of excavation or backfill.

1.5 ENGINEERING AND SURVEY WORK

A. The contractor shall engage the services of a registered Land Surveyor to stake the location and elevation of all parking areas, catch basins, curbing, etc.\

B. Submit two (2) copies of As-Built Drawings upon completion and acceptance of work..As-Built Drawings shall be complete and shall indicate the true measurement and location, horizontal and vertical, of all grading, drainage structures and new construction. As-Built drawings shall also contain any additional information required by the Owner's representative and shall be stamped by a licensed Land Surveyor.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Except as otherwise specified, all fills, refills and backfills within the building areas and for paved areas, utilities, and appurtenances required in structural or site excavation shall be made with gravel, crushed stone or sand as hereinafter specified.

1. Bank or Crushed Gravel shall be composed of hard, durable stone and coarse to fine sand, not frozen and free form loam and undesirable organic matter, containing no stone having any dimension greater than two-thirds (2/3) of the depth of layer to be compacted. Gravel borrow or bank-run gravel shall conform to article m.02 of the CONNDOT standard specification form 816 and the following gradation requirements:

% PASSING BY WEIGHT	U.S. STANDARD SIEVE SIZE
3 1/2"	100
1 1/2"	55-100
No. 4	25-60
No.40	5-25
No. 200	0-5

2. Processed aggregate shall conform to the applicable requirements of CONNDOT Standard Specifications Form 814 section M.05 and shall have the following gradation:

% PASSING BY WEIGHT	U.S. STANDARD SIEVE SIZE
2 1/4"	100

2"	95-100
3/4"	50-75
1/4"	25-45
No. 40	5-20
No. 100	2-12

3. Material for use as pipe bedding shall conform to the following requirements:

It shall be sand or sandy soil all of which passes a 3/8" sieve and not more than 10% passes a No. 200 sieve.

B. Common borrow and all refills and fills not supporting or influencing structures, pavement, or utilities shall be made with approved granular material containing sound stone, gravel and sand, free of frozen materials, silt, clay, vegetation, roots, peat, muck or other unsuitable matter.

C. The use of on-site materials for fills, refills, or backfills will be permitted provided the material meets the above requirements. Additional material required for structure fill shall be provided from off-site sources and shall meet the above requirements.

D. For lab testing see Div. 1.

3 PART 3 - EXECUTION

3.1 UNSUITABLE OR EXCESS MATERIALS

A. All topsoil and unsuitable or excess materials shall be stripped to their entire depths from areas of new construction or regrading. Materials suitable for use shall be stored in approved locations that will not interfere with building or utility operations. Topsoil shall be stripped and stored before any underlying excavating is begun. Stripped topsoil to be reused shall be free from clay, large stones and debris. Excess topsoil shall remain the property of the Owner and shall be loaded onto Town trucks, by the contractor, at the conclusion of the project. All unsuitable and surplus materials shall be excavated and legally disposed of off-site.

3.2 GRADES AND ELEVATIONS

A. The Drawings indicate, in general, the alignment and invert and finished grade elevations of all structures and utilities; the Owner's Representative, however, may make such adjustments in grades and alignment as are found necessary in order to avoid interference and to adapt the utilities and piping to other special conditions encountered. Grading between indicated final grades shall provide smooth even surfaces, except as otherwise required. Cover over pipes shall, in any case, conform to requirements of local and state agencies having jurisdiction.

3.3 SEQUENCE OF EARTHWORK

A. Within the Contract area operations to conform to a specified sequence of general excavation, structure excavation as required for footings, slabs and foundation units, backfill and completion of the subgrade, will be conducted.

B. The subgrade is herein defined as the top surface of those existing materials, and of fills and refills, not including base materials or surface materials.

C. After clearing and grubbing, and stripping of topsoil and unsuitable or excess materials, excavate and remove all materials above the subgrade level.

D. Excavation shall be performed to elevations and dimensions indicated, plus sufficient space to permit erection of forms and shoring, drains, masonry and the inspection of foundations.

E. Immediately after excavations to the required grades, the exposed surface of the in-site materials shall be cleaned of all loose or disturbed materials. The surface of all structural excavations shall be thoroughly compacted.

F. If suitable bearing for foundations is not encountered at the depth indicated on the Drawings, or in the excavations required in these Specifications, immediately notify the Owner's Representative. Remove any remaining unsuitable material as directed. The Owner's Representative shall be the sole judge of the suitability of all materials. Placing of footings, foundation walls or compacted gravel on unsuitable material will not be permitted.

G. If rock is encountered at the required elevations, the rock shall be over-excavated and replaced with a minimum of twelve (12) inches of compacted gravel to the elevation of the bottom of the footing.

H. Bottoms of excavations shall be protected from frost and from water whatever the source. Foundation units, footings or slabs shall not be placed on frozen ground nor on saturated materials. No excavation shall be made to the full depth indicated when freezing temperatures may be expected, unless the footings or slab can be poured immediately. The bottoms so excavated shall be protected from frost and water if placing or concrete is delayed.

I. The Contractor shall sheet, shore and brace all excavations, if necessary, to prevent cave-ins. Sheeting, shoring and bracing shall be removed before backfilling is completed.

J. Required excavations and excavations below or beyond the indicated or authorized limits shall be refilled with gravel compacted to the indicated percent of the maximum dry density at optimum moisture content as specified herein at no additional expense to the Owner's Representative.

95%	Pavement
85%	General

K. After all required excavations have been made and the footings, foundations units and foundations walls have been constructed the Contractor shall place and compact suitable backfill to the subgrade level in lifts as hereinafter specified.

L. All fills and refills to the subgrade level shall be made with approved materials as specified. Immediately prior to placing the improvements, clean up the subgrade by removing and replacing any unsuitable materials as previously defined.

3.4 SITE EXCAVATION, FILL AND BACKFILL

A. Perform all site excavation, fill, backfill and compaction required for the various utilities, structures, conduits, roads and appurtenances thereto and for all site grading.

B. Trench widths shall be sufficient to permit proper installation of the work and bottoms of trenches shall be evenly graded. The maximum allowable width of trench for pipe shall be as indicated on the Drawing. Excavations below required depths shall be refilled with compacted gravel. Immediately after trench excavations have been carried to the required grades, the exposed surface of the existing bottom materials shall be cleaned of all loose or disturbed materials. Where the trench bottom is below the water level or within saturated earth materials, the bedding shall be crushed stone. Pipe beds shall rounded to accommodate the bottom quadrant of the pipe and bell holes shall be excavated to provide full support and uniform bearing for the entire length of the pipe barrel.

C. After piping and conduits have been installed, tested, inspected and approved by the Owner's Representative, gravel in which stones larger that 2 inches in size have been removed, unless otherwise detailed on the Drawings, shall be carefully hand placed and hand tamped in six (6) inch layers under, around, and to a level one (1) foot above the top of the piping and conduits. The remaining excavation shall be backfilled with approved granular materials from on-site excavations, compacted in one (1) foot layers loose measure.

D. Information shall be obtained from the proper authorities concerning locations of all utilities within the scope of this work, in order that there will be no damage done to such utilities. Neither the Owner nor the Owner's Representative shall be responsible for any such damage and any resultant damage shall be restored to any structure and repaired without additional compensations.

    1. Rules and regulations governing the respective utilities shall be adequately protected from damage, and shall not be removed or relocated except as indicated or directed. Inactive and abandoned utilities encountered in excavation and grading operations shall be removed, plugged or capped, as directed. The locations of such abandoned utilities shall be reported in writing to the Owner's Representative.

E. Excavation of earth beyond indicated or authorized limits shall be refilled, at no additional expense to the Owner, with gravel compacted to 85 percent of the maximum dry density as required by the Owner's Representative.

F. Excavations shall be adequately sheeted, shored and braced, as necessary, to permit proper excavation of the work and to protect all slopes and earth banks. Sheeting shall be installed as required to prevent cave-ins or settlement and to protect workmen, adjacent structures and utilities. Shoring and sheeting may be removed as the backfilling progresses, but only when banks are safe against caving. The Owner's Representative may direct that sheeting, shoring and bracing, be left in place at any time during the progress of the work, and direct that timber be used for sheeting and bracing, authorized to be left in place, be cut-off at a specified elevations. In removing sheeting or bracing, care shall be taken to prevent voids. Voids, if formed, shall immediately be filled with sand. Dewatering shall be performed, as required, for all excavations below ground water level.

G. Dig test pits at the locations selected and to the dimensions directed by the Owner's Representative for compaction testing or to establish locations of existing pipelines or any other buried item for which the exact location is to be determined. The excavation, protection and backfilling of test pits shall be in accordance with the provisions of this Section. The maximum depth of test pits shall generally be ten (10) feet, measured from the average ground surfacing existing at the test pit location immediately prior to digging each pit. Test pits shall be backfilled with approved materials and compacted to the densities specified.

3.5 ROCK EXCAVATION

A. All rock encountered within the limits of excavation shall be removed as may be required to complete the work of this contract, as shown on the Drawings and as specified herein.

B. Rock excavation shall include only excavation of boulders of more than 1 cubic yard in volume and ledge rock which is determined by the Engineer to be so hard that it is necessary to loosen and handle with special rock breaking equipment or blasting.

C. Where boulders are exposed on the sides of, or in the bottom of the trenches or excavations for structures, they shall be wholly or partially removed, as directed; boulders shall be removed to limits not less than twelve (12) inches below and to the trench width lines indicated, and shall be removed to limits not less than twelve (12) inches outside below the structure walls or the underside of structure foundation slabs. Depressions resulting from the removal of boulders shall be refilled with approved compacted gravel.

D. The Contractor may excavate the rock by any method which is satisfactory to the Engineer and which will prevent damage to existing surfaces and structures adjacent to the work. The approval of the method of excavation shall not be construed as relieving the Contractor of any of his responsibilities or liabilities for damages.

E. The Contractor shall exercise great care in the use of explosives to prevent damage to adjacent property and shall comply with all Federal, State and City ordinances governing the handling, storage and use of explosives and shall obtain the necessary permits at his own expense.

F. The Contractor shall employ only experienced supervisors and workmen in the handling, loading and firing of dynamite. All employees engaged in this work shall be properly licensed by the State of Connecticut for the handling of explosive. Where explosives are used, work shall be done by experienced powdermen, using properly sized charges and in strict accordance with all regulations governing this work. The Contractor shall take every precaution to protect persons, property and the work.

3.6 PLACING FILL

A. Foundations for fills, refills and backfills shall be prepared in an approved manner by removing all excess and unsuitable materials. The base or other surface of fills, refills or excavations which have been allowed to weather and which in the option of the Owner Representative, are unsuitable, shall be removed and replaced with crushed stone or gravel or shall be dried, roughened or scarified, and then compacted before any additional fills or refills are placed on them.

B. Materials placed shall, unless permitted or required, be specially compacted by depositing in approximately horizontal layers not exceeding six (6) inches in thickness before compaction and, unless sufficiently moist as spread, shall be wetted to near the optimum moisture content. Each layer shall be compacted by suitable vibratory compactors or tampers, as previously approved by the Owner Representative, which will secure the required minimum degree of compaction. No other type of equipment shall be used for compaction.

C. Materials used in refills and backfills shall be deposited carefully to avoid injury to structures, conduits or pipes.

D. The areas to be fine graded for loaming and seeding shall be raked to remove all stones and other unsatisfactory material and shall then be rolled as directed under this Section. Any depressions which may occur during the rolling shall then be filled with additional suitable material and the surface then regraded and rolled until true to the lines and grades required. Care shall be taken not to affect the line or grade of walls and footings during grading and rolling operations.

3.7 COMPACTION

A. Fills placed under pavements, utilities and storm drainage systems shall be compacted to not less than 90 percent of the ASTM maximum dry density, except that the top six (6) inches below subgrade shall be compacted to 95 percent of maximum dry density. Fills in playing fields and planting areas shall consist of approved on-site material and shall be compacted to not less than 85 percent of the ASTM maximum dry density.

B. Where vibratory compaction equipment is specified herein or is directed to be used by the Owner's Representative all such equipment whether plate-type or roller shall be furnished with a vibrating surface at least 24 inches in width, and capable of operating at a minimum of 2,000 blows per minute. Equipment not specifically designed as vibrating compaction equipment shall not be permitted for compaction of either existing in-place materials or of fills, refills and backfills. Jack hammers, rubber-tired vehicles and similar equipment not specifically designed and manufactured for compaction of granular materials will not be approved for use.

C. Surfaces to be compacted shall, unless otherwise specified, be compacted by not less than six (6) complete passes of approved vibratory compactors, in order to obtain the required percentage of compaction. A complete pass shall consist of the entire coverage of the surface area to be compacted with one trip of the equipment. Each trip of equipment shall overlap the previous trip by at least one (1) foot.

D. Dumping, spreading preparing and compacting of several layers of fill materials across the site may be performed simultaneously, providing there is sufficient total area to permit these operations to proceed in a systematic manner.

E. No rolling equipment shall be used to compact fill, refill or backfill materials within five (5) feet of the vertical faces of any concrete walls or utility pipes. Plate vibratory tampers shall be used in these restricted areas, and in other areas too confined to satisfactorily use rolling equipment.

F. It is the intent of these compaction requirements that the minimum in-place dry density of the compacted materials resulting will be equal to or greater than the

minimum percentage specified herein. Additional compaction shall be required if the minimum percentages of ASTM in-place dry densities as specified are not obtained.

END OF SECTION

SECTION 312319 - DEWATERING

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 RELATED SECTIONS

A. Other specification Sections, which directly relate to the work of this Section, include:

1. Section 312000 “Earth Moving”

1.3 DESCRIPTION OF THE WORK

A. The Contractor shall prevent surface water and subsurface or groundwater from flowing into excavations or earthwork areas which would cause flooding of the Project site and surrounding area or softening or loosening of the soil at excavation or earthwork subgrade.

B. The Contractor shall provide adequate and satisfactory dewatering and drainage of excavations and furnish all materials and equipment and do all incidental work required in conjunction with the furnishing, installing, and maintaining of same to permit proper and timely completion of all work required. The Contractor may choose any satisfactory method he/she wishes subject to the approval of the Owner’s representative for handling groundwater or surface water encountered in the work, provided they perform the dewatering required. The Contractor shall assume all responsibility for the adequacy of the methods, materials, and equipment employed. The Contractor shall take all precautions necessary to prevent loosening or softening of the subgrade. In this regard, the Contractor shall at all times be prepared to alter his construction method or sequence. Dewatering and control of water shall be conducted as necessary to prevent seepage, groundwater flow, or surface infiltration and runoff from it in any way undermining or otherwise damaging adjacent structures and utilities.

C. Pumping equipment and devices to properly remove and dispose of all water entering the trenches and excavation for structures shall be provided. The grade shall be maintained dry until the structures (building slabs and footings, paved area, pipe, drainage structure, embankments, etc.) to be built thereon are completed. All dewatering required by pumping and drainage shall be performed without damage to the excavation, pipe trench, pavements, pipes, electrical conduits, other utilities, and any other work or property. Existing or new sanitary sewers shall not be used to dispose of drainage.

D. The Contractor’s method of dewatering shall maintain the bottom of excavations dry at all times.

E. The Contractor shall prevent pollution from storm water discharges in compliance with the DEEP General Permit for Discharge of Storm Water and Dewatering Wastewaters from Construction Activities (General Permit) and all other local, state, and federal requirements.

1.4 DESIGN CRITERIA

A. The Contractor is responsible for the adequacy of the dewatering systems and shall design the dewatering systems so they will:

1. Effectively reduce the hydrostatic pressure and lower the groundwater levels to a minimum of 2 feet below the bottom of excavation.
2. Develop a substantially dry and stable subgrade for the prosecution of subsequent operations.
3. Not result in damage to adjacent properties, buildings, structures, utilities, and other work.
4. Assure that, after 12 hours of initial pumping, no soil particles will be present in the discharge.

B. Methods may include sump pumping, single or multiple stage well point systems, educator and ejector-type systems, deep wells, and combinations thereof.

C. Locate dewatering facilities where they will not interfere with utilities and construction work to be done by others.

D. Modify dewatering procedures, which threaten to cause damage to new or existing facilities, so as to prevent damage. The Contractor is responsible for determining the modifications to be made, which shall be at no additional expense to the Owner.

1.5 SUBMITTALS

A. Prior to installation of the dewatering system, submit design data showing the following, for review by the Owner's representative:

1. The proposed type of dewatering system.
2. Arrangement, location, and depths of system components.
3. Complete description of equipment and instrumentation to be used, with installation, operation, and maintenance procedures.
4. Types, sizes, and location for the dewatering wastewater filtration system.
5. Design calculations demonstrating adequacy of the proposed system and equipment.
6. Methods of disposal of filtered dewatering wastewater.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 JOB CONDITIONS

A. Surface Drainage: Intercept and divert precipitation and surface water, away from excavations through the use of temporary diversion swales, temporary sediment traps, pipes, sumps, or other approved means.

B. Drainage of Excavated Areas: Provide and maintain ditches of adequate size to collect surface and seepage water, which may enter the excavations. Divert the water into the temporary sediment trap(s), sumps, and storm drains or pump into drainage channels or storm drains. When water is to be diverted into a storm drain, provide dewatering settling basins, or other accepted apparatus, such as fractionation tanks, as required to reduce the amount of fine particles, which may be carried into the drain. If a storm drain becomes blocked due to dewatering operation, it shall be cleaned by the Contractor at their own expense.

3.2 DEWATERING

A. Accomplish dewatering in accordance with accepted design data and applicable dewatering permits. Keep the Owner's representative advised of any changes made to accommodate field conditions and, on completion of the dewatering system installation, revise and resubmit design data as necessary to show the installed configuration.

B. Organize dewatering operations to lower the groundwater level in excavations as required for prosecution of the work, and to provide a stable, dry subgrade for the prosecution of subsequent operations.

C. Maintain the water level at such lowered elevations that no danger to structures can occur because of the buildup of excessive hydrostatic pressure on the subgrade, or bottom of trench, unless otherwise permitted by the Owner's representative.

D. Do not allow water to accumulate in excavations. The Contractor shall, at all times during construction, provide ample means and devices with which to remove promptly and dispose properly of all water entering roadway, trench, and structure excavations and keep them dry until the structures to be built thereon are completed.

E. No pipe/culvert/structure shall be laid in water. No masonry shall be laid in water, and no water shall be allowed to rise over masonry (either concrete or brick) in 24 hours after being placed. Nor shall moving water be allowed to rise over masonry for four (4) days. In no event shall water be allowed to rise so as to set up unequal pressures in the structures until the concrete or mortar has set at least 24 hours. The Contractor shall constantly guard against the possibility of flotation of pipe or structures after installation. He/She shall place adequate backfill promptly in accordance with Section 312000 "Earth Moving", to prevent this occurrence, and his/her method of handling drainage and carrying on these operations shall always be adequate to prevent flotation.

3.3 RECORDS FOR WELL SYSTEMS (IF USED)

A. Observe and record the average flow rate and time of operation of each pump used in the dewatering system. Where necessary, provide appropriate devices, such as flow meters, for observing the flow rates. Submit the data, in tabular form during the period that the dewatering system is in operation.

B. Observe and record the elevation of the groundwater on a form during the period that the dewatering system is in operation. Submit observation records within 24 hours of reading, on a regular basis.

C. During the initial period of the dewatering, make required observations on a daily basis. If, after a period, dewatering operations have stabilized, reduce observations to longer intervals as accepted by the Owner's representative.

END OF SECTION 312319

SECTION 315000 - SHEETING AND STAYBRACING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF THE WORK

A. The Contractor shall install sheeting or staybracing as necessary in order to comply with the applicable Safety Code; to accommodate traffic; to permit access to existing utilities; to provide an opening of proper depth and width in which to install the proposed pipes and other underground structures; and to protect his workmen, employees of the Owner, and the public, from death or injury from bank failure, earth collapse, or earth movement of any nature whatsoever. In general, all trenches and excavations over 4 feet in depth, any other unstable excavations, or excavations in unstable material, shall be protected against the hazard of collapse.

1.3 SHEETING/STAYBRACING DESIGN

A. The Contractor shall be entirely and solely responsible for the adequacy and sufficiency of all supports and for all sheeting, bracing, shoring, underpinning, cofferdamming, etc. The Contractor shall assume the entire and sole responsibility for damages on account of injury to persons or damage to adjacent pavements and public and private property (including but not limited to, the Work under construction, existing buildings, facilities, etc. which injury or damage results directly from said Contractor's failure to install, or to leave in place, adequate and sufficient supports, sheeting, bracing, underpinning, cofferdamming, etc.

B. The Contractor shall submit, in triplicate, a detailed written description of the equipment and sheeting methods he proposes to use to the Owner’s representative prior to the installation of any sheeting and/or shoring. These plans should include, but not be limited to, the type of sheeting or shoring, sizes and dimensions, bracing, spacing, methods of installation and removal, etc.

C. All sheeting shall be designed and sealed by a Professional Engineer licensed to practice in the State of Connecticut. He/She shall be known as the Contractor's Engineer. Sheeting computations and sketches shall be submitted for the Owner’s representative's review.

1.4 SHEETING LEFT-IN-PLACE

A. Sheeting, shoring, or other timbering may be left-in-place at the option of the Contractor when needed to protect other existing facilities or the Work built or to be built under this Contract. However, steel sheeting left-in-place will be paid for only where specifically shown as "Steel Sheeting Left-in-Place" on the Contract Drawings or where ordered by the Owner’s representative.

B. It is expressly understood and agreed that removing or leaving-in-place any sheeting or shoring, etc., as noted above, shall not relieve the Contractor from any responsibility for any loss damage whatever due to omission of, or failure of, the sheeting, etc., failure to leave it in place, or the settling of the backfill, or any movement of the ground or any structure or object adjacent to any trench or excavation made by the Contractor. The Owner’s representative will not order any sheeting, etc.

left-in-place at the expense of the Owner in order to accommodate the convenience of the Contractor or to save him/her the cost of its removal.

1.5 OPTIONAL METHOD OF TRENCHING

A. The Contractor may, with the approval of the Owner's representative, lay back slopes in accordance with the provisions of the applicable local, State, or Federal Safety Code in order to avoid the necessity of sheeting or limiting the quantity thereof. However, in the case of trenches, the toe of this slope will not be lower than 1 foot above the top of the pipe to be installed. A level bench of at least 2 feet in width shall be maintained between the toe of the sloped section and vertical trench excavation for pipes with an outside diameter of 6 feet or less; for pipes with an outside diameter over 6 feet, a minimum 4-foot bench shall be provided. Where sloping is used as a substitute for sheeting or staybracing, or used in combination therewith, it shall be sloped a minimum of one (1) horizontal to one (1) vertical except where instability of the material requires a slope flatter than one to one. If the Contractor elects and is allowed to lay back the slopes, there will be no additional payment made for the extra excavation outside of the normal trench or structure excavation payment limits.

1.6 RESPONSIBILITY OF THE OWNER'S REPRESENTATIVE

A. There shall be no obligation on the part of the Owner's representative to issue orders for sheeting, staybracing, or sheeting left-in-place and/or to pass upon sufficiency and adequacy of sheeting; nor shall the failure on the part of the Owner's representative to give such orders relieve the Contractor from liability for damages occasioned by negligence, or otherwise growing out of the Contractor's failure to either install sufficient and adequate sheeting and/or staybracing or to leave in place in the excavation sufficient and adequate support to prevent the caving in or moving of the ground adjacent to the sides of the excavation during and after the backfilling operation.

PART 2 - MATERIALS

2.1 MATERIALS

A. Wooden staybracing, shoring, and sheeting shall be in conformance with the requirements of Connecticut DOT Form 816, Subarticle M.09.01-1.

B. All steel sheeting shall be continuous and interlocking with materials conforming to the provisions of ASTM A 328 or equal.

2.2 TRENCH BOXES

A. Trench boxes shall not be used unless requested by the Contractor and authorized by the Owner's representative. If authorized, they shall be used only when the protection of workmen is involved, not for support of existing adjacent utilities, structures, embankments, etc. A trench protected by the use of a trench box shall not be considered a sheeted trench.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Unless expressly authorized by the Owner's representative, sheeting shall be driven ahead of the excavation to avoid loss of material from behind the sheeting. If it is necessary to excavate below the sheeting to facilitate driving, care shall be taken to avoid trimming behind the face

along which the sheeting will be driven. Care shall be taken to prevent voids outside of the sheeting.

B. All sheeting and staybracing shall be securely installed and properly braced in accordance with the applicable local, State, or Federal Safety Code. The Owner's representative may direct the Contractor at any time in writing to have sheeting, bracing, etc. in place to be embedded in backfill or concrete for the purpose of preventing subsequent injury to structures and property.

C. The depth of pilot cuts for trenches/structures shall not exceed 5 feet in depth at any time. The Owner's representative may reduce the depth of the pilot cut should the soil and subsurface conditions warrant such action. Sheeting must be driven by drop hammer or other methods approved in writing by the Owner's representative below the area of the pilot cut. Driving of sheeting above the pilot cut is subject to the directions of the Owner's representative. The Owner's representative may direct the Contractor to use other types of equipment, and to revise the procedure during the excavation of the pilot cut and the driving of the sheeting should it be found necessary to do so.

D. Vibratory driving hammers shall not be used unless specifically authorized by the Owner's representative.

E. Where sheeting is specified to be left-in-place, it shall be wood sheeting unless otherwise specifically noted on the Contract Drawings. Where wooden sheeting cannot be driven due to the nature of the material, then steel sheeting may be driven and removed in lieu of the wooden sheeting providing the following procedures are followed:

1. Simultaneously with the withdrawal of sheeting and as each layer is compacted in accordance with Section 312000 "Earth Moving"; or
2. The trench/area will be backfilled to the surface. If the sheeting is to be withdrawn, backfilling will proceed up to each set of rangers and braces; the rangers and braces will be removed; the backfilling will proceed up to the next set of rangers and braces, etc. up to the top of the excavation. The backfill material shall be compacted to ninety-eight percent (98%) of the maximum dry density as determined by AASHTO T 99, Method C. Alternate sections of sheeting from the left side and right side of the trench/area shall be removed and the cavity remaining there from shall be jetted thoroughly by high-pressure water, starting at the toe of the sheeting and being drawn to the surface. Sand shall be inserted with the jetting process.

F. Where the bottom of the excavation is not free draining material (some areas of organic material or miscellaneous fill) or where granular backfill is not available or ordered by the Owner's representative, the jetting shall be very carefully done with a minimum amount of water being expended. In such locations, the Contractor may request the approval of the Owner's representative for other compaction methods in the sheeting cavity.

G. The Contractor shall remove the sheeting and/or staybracing from the excavation, except where it is specifically indicated on the Contract Drawings "To be Left- in-Place", or the Contractor may elect to leave in place the sheeting and/or staybracing for his/her own convenience, or to serve his/her own interest to protect existing facilities, the Work built or to be built under this Contract, or for the safety of the public, etc., at no cost to the Owner. No sheeting or bracing which is within 3 feet of the existing or proposed finished grade may be left-in-place without the prior permission of the Owner's representative. This may require the Contractor cut off sheeting at this elevation and at no additional cost to the Owner.

H. Where sheeting, regardless of the type of sheeting used, is left in place, as specified, ordered, or at the Contractor's convenience/option, unless otherwise specifically permitted in writing by the Owner's representative, all elements such as rangers, braces, wales, etc. shall be left in place except as specified hereinbefore; and, except such temporary braces required to be

removed to make way for the structure/utility. Where it is necessary to remove such temporary braces, the sheeting shall be rebraced, but in no case shall the sheeting be braced against the sides of the structure/utility to be constructed unless approved in writing by the Owner of the structure/utility. Where lagging and "soldier" beams are used, the "soldier" beams and all the braces shall also be left in place.

I. Where wood sheeting has been driven below the excavation bottom to provide for a "toe-in", no wood sheeting below the top of pipe or structure shall be removed, but it shall be cut off at this elevation and the remaining sheeting above this line removed as described herein. There will be no payment made for this work, nor for the wood sheeting left-in-place.

J. Sheeting shall be cut away and removed from in front of capped outlets or other braces or inlets set in the pipe for future connections.

K. All sheeting, shoring, and bracing removed shall be carefully removed from the excavation in such a manner as not to endanger the completed work or any adjacent pavements, buildings, structures, utilities, property, etc. The sheeting shall be withdrawn to such an extent that it is just above the backfill material being compacted, and all voids left or caused by the withdrawal of such sheeting, shall be immediately refilled with approved material and compacted at no additional cost to the Owner.

L. Where the excavation is to be left open during non-working hours, the sheeting shall extend 42 inches above existing grade to protect pedestrian and vehicular traffic from the open excavation. If barricades are not used, such sheeting shall be suitably lighted, conforming to the Section 317000 “Maintenance and Protection of Traffic”.

END OF SECTION 315000

SECTION 317000 - MAINTENANCE AND PROTECTION OF TRAFFIC

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 DESCRIPTION OF THE WORK

A. The Work under this Section shall consist of maintaining and protecting traffic in and adjacent to the project area to the satisfaction of the applicable local Police, Fire, and Traffic Departments and the Owner's representative. Unless otherwise specified within the Contract Documents, the Contractor must maintain pedestrian and vehicular traffic and permit access to parking lots, parking garages, buildings, and intersecting streets.

1.3 WORK BY OTHERS

A. The Contractor is advised that he shall coordinate the maintenance and protection of traffic, both vehicular and pedestrian for the entire job. The Contractor shall insure that the provisions provided herein shall be complied with by all parties involved in work on this Contract.

1.4 MAINTENANCE AND PROTECTION OF TRAFFIC EQUIPMENT

A. The equipment used under this Item shall comply with all requirements herein and the requirements of the 1988 Manual on Uniform Traffic Control Devices for Streets and Highways, as amended. Traffic drums shall be used to separate moving lanes of traffic from the Work area. Each drum shall be affixed with high intensity flashers for nighttime operation.

B. Type I barricades shall be used to barricade off work zones from operating travel lanes and parking lanes. Each barricade shall be affixed with suitable construction signs.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TRAFFIC CONTROL

A. The Contractor shall furnish, light, and maintain such signs as may be directed, or may be necessary, for the safe regulation, and convenience of traffic. Said signs will be as specified on the Contract Drawings or elsewhere herein, or if not specified, they shall be adequate for the regulation, safety, and convenience of traffic and in conformance with the applicable requirements of the State/Federal Manual on Uniform Traffic Control Devices. All signs shall be subject to the approval of the Owner's representative. The Contractor shall provide, erect, and maintain suitably lighted barricades, warning lights, etc. as needed, or as directed in order to keep people, animals, and vehicles from excavations, obstacles, etc. The Contractor may be required to employ traffic men and take other such reasonable means or precautions as the Owner's representative may direct, or as may be needed to prevent damage or injury to persons, vehicles, or other property and to minimize the inconvenience and danger to the public by his construction operations. He shall arrange his operations to provide access to properties

along the street, including temporary bridges to driveways, and provide access to fire hydrants, manholes, gate boxes, or other utilities. Whenever any trench obstructs traffic in, or to, any public street, private driveway, or property entrance, the Contractor shall take such steps as required to maintain necessary traffic and access, including temporary bridging if required. The Contractor shall confine his occupancy of public or traveled ways to the smallest space compatible with the efficient and safe performance of the Work contemplated by the Contract.

B. The Contractor shall observe and obey all local and state laws, ordinances, regulations, and permits in relation to the obstruction of streets and highways, keeping passageways open, and protecting traffic where there may be danger from blasting or other construction activities.

C. Suitable lighted barriers or barricades shall be furnished by the Contractor and put up and maintained at all times during the night or daytime, around all open ditches, trenches, excavations, or other work potentially dangerous to traffic. Such barricades shall be as shown on the Contract Drawings, or if not shown, will be constructed of 2-inch by 8-inch rough lumber, securely supported and braced at least 3 feet high above the ground. Barricades shall be placed on all sides and throughout the entire length and breadth of all open ditches, trenches, excavations, or other work, which must be barred to the general public. Barricades shall be properly painted to the satisfaction of the Owner’s representative in order to retain a high degree of visibility to vehicular and pedestrian traffic.

D. Suitable lighted barricades shall be defined as barricades lit by flashers in accordance with this paragraph or other lighting methods approved by the Owner’s representative in lieu thereof. Flashers shall be placed along the entire length of the barricades at an interval no greater than 8 feet, center to center. Flashers shall be power operated, lens directed, enclosed light units which shall provide intermittent light from seventy to one hundred twenty (70-120) flashes per minute, with the period of light emittance occurring not less than twenty-five percent (25%) of each on-off cycle, regardless of temperature. The emitted light shall be yellow in color and the area of light on at least one (1) face of the unit shall be not less than 12 square inches. The discernible light shall be bright enough to be conspicuously visible during the hours of darkness at a minimum distance of 800 feet from the unit under normal atmospheric conditions. For units, which beam light in one (1) or more directions, the foregoing specifications shall apply 10 degrees or more to the side and 5 degrees or more above and below the photometric axis.

E. The Contractor shall furnish and securely fasten flashing units to signs, barricades, and other objects in such numbers and for such lengths of time as are required for the maintenance and protection of traffic, or as the Owner’s representative may order. The flasher shall be in operation during all hours between sunset and sunrise, and during periods of low visibility. The Contractor shall maintain, relocate, and operate barricades and flashers throughout the life of the Contract. No special payment will be made for barricades or flashers.

F. Should the Contractor or his employees neglect to set out and maintain barricades or lights, as required in these Specifications, the Owner’s representative immediately, and without notice, may furnish, install, and maintain barricades or lights. The cost thereof shall be borne by the Contractor and may be deducted from any amount due, or to become due, to the Contractor under this Contract.

G. The Contractor will be held responsible for any damages that the Owner, Owner’s representative, Governmental units, or their heirs or assigns may have to pay as a consequence of the Contractor's failure to protect the public from injury, and the same may be deducted from any payments that are due or may become due to the Contractor under this Contract. The Contractor shall allow for bridging for trenches at all street and driveway crossings in such manner as the Owner’s representative may direct in order that the traffic on intersecting streets may not be blocked, and in order that entrance may be made to properties along the line of work.

3.2 MAINTENANCE OF TRAVEL LANES

A. During non-construction hours, weekends, and holidays, a minimum of two (2) 12-foot-wide travel lanes shall be open to traffic. Trenches shall be either temporarily paved or covered with skid resistant steel plates, unless otherwise directed by the Owner's representative. Steel plates to be designed to withstand the normal traffic loads. Also, during the above mentioned times, all driveways shall be accessible to vehicular traffic.

B. During construction hours, the Contractor will be allowed to close the streets to through traffic, provided alternate detour arrangements are made which are acceptable to the Police, Fire, and the Owner's representative. The Contractor shall notify the local Police, Fire, and Ambulance Services 72 hours in advance of any/or all street closures, or partial closures.

3.3 SNOW REMOVAL

A. If the Contractor's operations or occupancy of any public street or highway, or the uneven surfaces over any trenches being maintained by the Contractor shall interfere with the removal or sanding of snow or ice by the public authorities or adjoining landowners, in an ordinary manner with regular highway equipment, the Contractor shall be required to perform such services for the public authorities or adjoining Owners without charge. If the Contractor fails to do so, he shall reimburse the said authorities or adjoining Owners or the Owner for any additional cost to them for doing such work occasioned by conditions arising from the Contractor's operations, occupancy, or trench surfaces, together with any damage to the equipment of said parties by those conditions or claims of any parties for damage or injury or loss by reason of failure to remove snow or ice or to sand icy spots under these conditions.

3.4 STREET DETOURS

A. Where detours will be required, the Owner's representative shall require the Contractor submit a proposed detour plan for all portions of the Work to the Owner's representative and to the applicable Local Regulatory Agencies. This submittal shall be made at least seven (7) days prior to commencing construction. It shall be the sole responsibility of the Contractor to keep the Local Regulatory Agencies (including, but not limited to, the Police and Fire Departments) forewarned at least 72 hours in advance of changes in traffic patterns due to reduction of pavement widths or closing of streets. The Contractor shall supply, install, maintain, replace as necessary, adjust, move, relocate, and store all signs, suitably lighted barricades, traffic cones, and traffic delineators, as necessary to carry out the traffic routing plan and maintain vehicular and pedestrian traffic. All this work shall meet with the requirements of the Local Regulatory Agencies and the Owner's representative. If additional signs and traffic protection is necessary beyond that shown in the Contract Documents, or if not shown, beyond that initially estimated by the Contractor, the total cost shall still be borne by the Contractor.

3.5 TEMPORARY DETOURS

A. Temporary detours shall be constructed on the site as directed by the Owner's representative, required by the Contract Drawings, or specified elsewhere herein. Said detours shall not have grades in excess of ten percent (10%) anywhere along their lanes unless otherwise shown on the Contract Drawings. Detours shall be smooth riding as determined by the Owner's representative.

B. Suitable barricades shall be installed continuously along both sides of a detour where (1) the adjacent side slope is steeper than 6:1; (2) the Contractor's operations or equipment may operate within 20 feet of the detour, or (3) other unsafe conditions require them for the protection of traffic along the line of detour.

3.6 TRAFFIC CONTROL PROCEDURES

A. The proper and adequate signing of the construction zone, and any approved detours, is considered of utmost importance. Prior to the start of construction, the Contractor shall submit a signing plan for review by the Owner's representative, Police, and Fire Departments.

B. The Contractor shall provide a minimum of at least one (1) flagman for each work crew within signed areas for the control and direction of vehicular and pedestrian traffic on as needed, or as directed, basis and at no cost to the Owner. This flagman shall be dedicated to traffic control only and shall not be utilized as part of the Work crew.

C. The Contractor shall provide uniformed policemen at major intersections and at other locations where the applicable Local Regulatory Agencies may determine their need for the control and direction of vehicular traffic and pedestrians.

END OF SECTION 317000

SECTION 320000 - CURBING

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 DESCRIPTION OF THE WORK

A. Provide all facilities, labor, materials, tools, equipment, appliances, transportation, supervision, and related work necessary to complete the Work specified in this Section, and as shown on the Drawings.

B. The Work of this Section includes, but is not limited to, the furnishing and installing of cast-in-place concrete curb and bituminous concrete lip curbs. Work shall also include all associated items and operations necessary and required to complete the installations, including, but not limited to, surface preparation, finishing and cleanup.

1.3 RELATED SECTIONS

A. Carefully examine all the Contract Documents for requirements that affect the Work in this Section. Other specification Sections that directly relate to the Work of this Section include, but are not limited to, the following:

1. Section 312000 “Earth Moving”
2. Section 321216 “Asphalt Paving”
3. Section 321314 “Site Cast-in-Place Concrete”

PART 2 - PRODUCTS

2.1 CAST-IN-PLACE CONCRETE CURB

A. Concrete and reinforcement for cast-in-place concrete curbs shall be as specified in Section 321314 “Site-Cast-in-Place Concrete”.

2.2 BITUMINOUS CONCRETE LIP CURBING

A. Bituminous concrete for curbing shall conform to the applicable requirements for Class 3 bituminous concrete as specified in Connecticut DOT Form 816, Article M.04.

PART 3 - EXECUTION

3.1 GENERAL

A. Trenching, excavation, backfilling, and compaction shall be completed in accordance with Section 312000 “Earth Moving”, except as modified within this Section.

3.2 BITUMINOUS CONCRETE LIP CURB

A. General Requirements

1. Bituminous curbing shall be constructed by the use of an approved self-propelled extruding curb machine equipped with a material hopper, distributing screw, and curb forming device capable of placing the bituminous mixture to the required lines, grades, and proper curb cross-section. Prior to the placement of any curb, the Contractor shall submit a detail of the cross-section of the curb mold that he proposes to use to the Owner's representative for approval.

B. Surface Preparation

1. When curbing is to be placed on existing bituminous pavements, concrete pavements, or newly laid bituminous pavements which have been in place more than 24 hours, the surface on which the curb is to be placed shall be swept and cleaned, thoroughly dried, and immediately prior to placement of the curb, the surface to be occupied by the curb shall be given an application of tack coat material. Particular care shall be exercised to prevent spread of tack coat material beyond the area to be occupied by the curb. Recently placed bituminous concrete pavement, which have been placed less than 24 hours prior to placement of the curb need only be thoroughly swept and cleaned.

C. Placing and Compaction

1. The hot bituminous mixture shall be placed in the hopper of the curb paver without segregation and extruded through the mold form to provide the proper compaction and surface texture.
2. The curb paver shall be properly supported and weighted during operation along the edge of the pavement and shall be guided along string or chalk lines to maintain the proper alignment and level of the completed curb.
3. Any portions of the completed curb, which are not satisfactorily compacted, or show signs of sagging, cracking, or distortion, or do not conform to the required lines, grades, or cross-section for any reason, and which cannot be satisfactorily repaired during construction, shall be removed and replaced at no additional cost to the Owner.

D. Joints: Bituminous curb construction shall be a continuous operation in one (1) direction only, to eliminate frequent joints. When the placing of the curb is discontinued for a length of time that permits the mixture to become chilled, the curb shall be cut in a true vertical plane and the exposed end painted with a thin uniform coat of hot asphalt cement just prior to placing the fresh curb mixture against the previously constructed curb to insure a continuous bond.

3.3 CONCRETE CURB (CAST-IN-PLACE)

A. General Requirements: Concrete curb shall be constructed of concrete and shall be cast-in-place to proper size and shape and to the line and grade shown on the Drawings. The curbing shall be constructed using conventional forms and in segments separated by construction joints and expansion joints as specified herein.

B. Forms: Forms shall be metal or acceptable planed and matched lumber, straight and free from warp or other irregularities that will adversely affect the installation. Forms shall conform to the curb cross-section shown on the Drawings and shall be carefully set to line and grade and thoroughly braced and secured in place so that there will be no displacement during placement of the concrete. All forms shall be thoroughly cleaned prior to reuse.

C. Placing of Concrete: Prior to placement of the concrete, the subgrade shall be moistened and the contact surfaces of the forms shall be given a light coating of oil that will not discolor the concrete. Concrete shall then be placed in the form as near to its final position as practicable, struck off with a template, spaded to prevent “rock-pockets” or “honey combing” adjacent to the forms, and finished to a smooth even surface. The concrete may be compacted by mechanical vibrators if approved by the Owner’s representative. Placing by slip form methods shall be approved by the Owner’s representative.

D. Expansion Joints: Vertical expansion joints shall be located approximately every 75 feet and shall be so arranged that they shall match expansion joints in any adjacent concrete pavements and sidewalks. Unless directed otherwise, expansion joints shall also be installed at the PC and PT of all radius curb. Expansion joints shall be constructed vertical, plumb, and at right angles to the face of the curb. They shall be ½-inch in width and formed with premolded bituminous joint filler cut to conform to the cross-section of the curb/curb gutter.

E. Construction Joints: Vertical construction joints shall be located approximately every 15 feet being equally spaced between expansion joints. The length of these curb/curb gutter segments may be varied slightly for closures but in no case shall they be less than 8 feet. Construction joints shall be vertical, plumb, and at right angles to the face of the curb and shall be formed by approved method that will provide complete separation of the curb segments during the placing of the concrete. If curb is formed by slip form methods, the joints shall be sawed as soon as practicable after the concrete has set to preclude raveling during the sawing and before any shrinkage cracking occurs in the concrete.

F. Finishing: Forms shall be left in place for 24 hours or until the concrete has sufficiently hardened as determined by the Owner’s representative, so that they can be removed without injury to the curb. Upon removal of the forms, the exposed faces of the curb/curb gutter shall be immediately rubbed to a uniform surface. Rubbing shall be performed by experienced and competent concrete finishers. No plastering will be permitted.

END OF SECTION 320000

SECTION 321200 - PREPARATION OF SUBGRADE/FINE GRADE

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 work shall consist of the preparation of the top surface of the roadbed, after all grading has been substantially completed and all pipes/conduits laid, to accommodate the placement of the pavement structure and gutters in accordance with these specifications and in conformity with the lines, grades, and typical cross-sections as shown on the Contract Drawings.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 PREPARATION OF SUBGRADE

A. All soft and yielding material and other portions of the subgrade which will not compact readily when rolled, vibrated, or tamped, shall be removed and replaced with suitable material. The surface shall be compacted uniformly with a minimum of four (4) complete coverages using an approved power roller having a minimum compression of 300 pounds per inch of width of tread on the rear wheel, and weighing not less than 10 tons, or with an equivalent vibratory roller or compactor.

B. When more than one (1) compacting unit is used, the unit exerting the greatest compactive effort shall be used to make the initial compaction. Any portion of the subgrade, which is not accessible to a roller or other compacting unit, shall be compacted thoroughly with hand tampers or with approved mechanical vibrators.

C. The Contractor shall notify the local authority for inspection of the subbase in public streets prior to placement of the base course.

3.2 FINE GRADING

A. After compaction, the top surface of the subgrade shall be fine graded so that it shall not extend above, nor more than ½-inch below, true grade and surface at any location. The subgrade shall not be muddy or otherwise unsatisfactory when pavement/base/subbase is placed upon it. If the surface of the subgrade becomes rutted or displaced due to any cause whatsoever, the Contractor shall regrade same at their own expense.

3.3 PROTECTION OF SUBGRADE

A. The Contractor shall protect the subgrade from damage by exercising such precautions, as the Owner’s representative may deem necessary. At all times, the subgrade surface shall be kept in such condition that it will drain readily and correctly. The subgrade shall be checked and approved before any pavement structure is placed thereon.

END OF SECTION 321200

SECTION 321216 - 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. Provide all facilities, labor, materials, tools, equipment, appliances, transportation, supervision, and related work necessary to complete the Work specified in this Section, and as shown on the Drawings.

B. The Work of this Section includes, but is not necessarily limited to:

1. Asphaltic (bituminous) concrete paving for new or repaired street, driveway, and parking area pavements.
2. Installation of bituminous concrete overlays over existing pavement, including surface preparation, truing and leveling pavement, tack coating, and all other associated items and operations necessary and required to complete the installation.
3. Adjust existing castings to finished grade.
4. Saw cut existing edge of pavements for the construction of a proper butt joint.

C. Related Sections

1. Carefully examine all the Contract Documents for requirements, which affect the Work in this Section. Other specification Sections, which directly relate to the Work of this Section include, but are not limited to, the following:

a. Section 312000 “Earth Moving”
b. Section 320000 “Curbing”
c. Section 321200 “Preparation of Subgrade/Fine Grade”

1.3 JOB CONDITIONS

A. Weather Limitations

1. Apply tack coat where indicated on the Drawings and when ambient temperature is above 40°F, and when temperature has been above 35°F for 12 hours immediately prior to application. Do not apply when base is wet, contains excess moisture, or during rain.
2. Construct bituminous concrete paving when atmospheric temperature is above 40°F and when base is dry.
3. The temperature of the mixture, within a tolerance of plus or minus 15°F, when delivered at the site will be governed by its temperature of the base upon which the mix is placed and the following table:

Air Temperature in Degrees F	Base Material Temperature in Degrees F For Course Thickness in Inches			
	1	1½	2	3 and Greater
35-40	--	305	295	280
41-50	--	300	285	275
51-60	300	295	280	270
61-70	290	285	275	265
71-80	285	280	270	265
81-90	275	270	265	260
91 & Over	270	265	260	255

1.4 SUBMITTALS

A. Design Mix: Before any bituminous concrete paving is constructed, submit actual design mix to the Owner's representative for review and/or approval. Design mix submittal shall follow the format as indicated in the Asphalt Institute Manual MS-2, Marshall Stability Method; and shall include the type/name of the mix, gradation analysis, grade of asphalt cement used, Marshall Stability (lbs.), flow, and effective asphalt content (percent).

B. Material Certificates: Submit Material Certificate to the Owner's representative, which is signed by material producer and Contractor, certifying that materials comply with, or exceed, the requirements herein.

1.5 COORDINATION

A. The Site Contractor shall coordinate with all other trades, especially underground Utility Contractors, in order to prevent covering up unfinished or uninspected work and loss of time or labor by improper scheduling. Any rework shall be done at no cost to the Owner.

1.6 PAVEMENT WITHIN PUBLIC RIGHT-OF-WAY

A. The installation of all pavements within the Public Rights-of-Way shall be in accordance with the rules, regulations, and requirements of the Public Agency having control and ownership of such Rights-of-Way. Work shall include all items and operations necessary and required to complete the pavement installation to the satisfaction of the authorities having jurisdiction.

1.7 SUBGRADE TESTING

A. Subgrade bearing capacity shall be determined by testing. The minimum CBR (California Bearing Ratio) shall be 10. The Contractor shall perform CBR tests as necessary, but in no case less than one (1) test for each 1,000 square yards of paved area.

B. The Contractor shall remove any subgrade areas not meeting the minimum CBR during subgrade preparation. Areas of subgrade removal shall be filled and compacted with suitable material at no extra cost to the Owner.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Mineral Aggregate

1. Coarse Aggregate shall be clean, crushed rock free from dirt or other objectionable material and shall have a percentage of wear, as determined by the Los Angeles Abrasion test (AASHTO-T96-02), of not more than 30.
2. Fine Aggregate shall consist of natural sand, stone sand, or a blend of natural sand and stone sand. The fine aggregate as delivered to the mixer shall meet the following requirements:

Sieve	Percent Passing Grading No. 1
3/8-inch	100
No. 4	95 to 100
No. 8	70 to 100
No. 30	20 to 65
No. 50	7 to 40
No. 200	0 to 10

3. The use of reclaimed asphalt pavement in new bituminous pavement will not be permitted.

B. Asphalt Cement: Comply with AASHTO M-226/ASTM D 3381-92; Table 2 for grades AC-10, AC-20, or AC-30, AR-8000, viscosity grade, depending on local mean annual air temperature. (See chart below):

Temperature Condition	Asphalt Grades
Cold, mean annual air temperature $\leq$7 degrees C) 45 degrees F)	AC-10 85/100 pen.
Warm, mean annual air temperature between 7 degrees C (45 degrees F) and 24 degrees C (75 degrees F)	AC-20 60/70 pen.
Hot, mean annual air temperature $\geq$24 degree C (75 degrees F)	AC-30

Final acceptance of the proper grade of AC shall be made by the Owner's representative.

C. Tack Coat: Emulsfied asphalt; AASHTO M140-70 or AASHTO M 208/ASTM D 2397-98, Grades RS-1, SS-1, SS-1H, CRS-1, CSS-1, or CSS-1H, diluted with one (1) part water to one (1) part emulsified asphalt.

D. Mineral Filler: Rock or slag dust, Portland cement, or other inert material complying with ASTM D 242-04.

E. Asphalt-Aggregate Mixture: Unless otherwise noted on the Drawings, the Design Mix shall have a minimum stability based on a 75-blow Marshall Method, complying with AASHTO T245, of 1200 lb. with a flow between 8 and 16. The Design Mix shall be within sieve analysis and binder ranges below:

SIEVE ANALYSIS OF MIX
PERCENT BY WEIGHT PASSING

Sieve	Class 1	Class 2	Class 3	Class 4	Class 12
2-inch	--	--	--	100	--
1-inch	100	--	--	--	--
¾-inch	90-100	--	--	60-80	--
½-inch	70-100	100	100	--	100
3/8-inch	60-82	90-100	95-100	42-66	98-100
¼-inch	--	--	--	--	--
No. 4	40-65	55-80	65-87	30-55	80-95
No. 8	28-50	40-64	40-70	20-40	60-95
No. 30	10-32	16-36	20-40	--	20-60
No. 50	6-26	8-26	10-30	5-18	10-40
No. 200	3-8	3-8	3-8	0-5	3-10
Grade of PG Binder	PG 64-28	PG 64-28	PG 64-28	PG 64-28	PG 64-28
Content Percent (%)	5.0-6.5	5.0-8.0	6.5-9.0	4.0-6.0	7.5-10.1
Voids	3.0-6.0	2.0-5.0	0-4.0	--	0-5.0

F. Geotextile Fabric: Geotextile fabric shall be Exxon Geotextile Fabric **GTF-300**, Geotex **315ST**, Contech Fabric **C300**, or approved equivalent.

2.2 BITUMINOUS CONCRETE

A. Bituminous concrete for sidewalks and driveways shall conform to Connecticut DOT Form 816, Section M.04 Class 2.

B. Bituminous concrete for roadways shall conform to Connecticut DOT Form 816, Section M.04 Class 1.

2.3 EQUIPMENT

A. Maintain equipment in satisfactory operating condition and correct breakdowns in a manner that will not delay or be detrimental to progress of paving operations.

PART 3 - EXECUTION

3.1 GENERAL

A. The Contractor shall install all on-site and off-site pavements as specified in the location and to the grades as shown on the Drawings and/or approved by the Owner's representative. Materials, methods of construction, and type and thickness of pavement courses shall be as shown on the Details of the Drawings and as specified herein.

B. The Owner and its representatives shall have access to all parts of the Work under construction at all times.

C. The Owner's representative shall permit the laying of bituminous concrete only between April 15th and November 15th, when the air temperature is 40 degrees Fahrenheit or warmer, and the temperature of the surface to be paved is 45 degrees or higher. Paving outside these limits requires written permission of the Owner's representative.

D. The pavement types and thicknesses as shown on the pavement details shall conform to the Connecticut DOT Form 816, Section M.04.02.

3.2 PREPARATION FOR PAVEMENT INSTALLATION

A. Remove loose material from compacted base material surface immediately before proof rolling.

B. Proof roll prepared base material surface to check for areas requiring additional compaction and areas requiring removal and recompaction.

C. Do not begin paving work until deficient base material areas have been corrected and are ready to receive paving.

D. Check all frames, covers, grates, water valve boxes and other miscellaneous castings that are located in the proposed pavement areas to ensure that all such items have been correctly positioned and set to the proper slope and elevation. All covers and grates are to be set flush with the required finished surface. No depressions or mounds will be permitted in the pavement to accommodate inaccuracies in the setting of these appurtenances. All correctional work that may be necessary, as determined by the Owner's representative, shall be performed at the Contractor's own expense.

E. All vertical surfaces of structures and existing concrete surfaces in contact with new bituminous pavement shall be painted with a uniform coating of an approved bituminous emulsion material. Extreme care shall be exercised in the application of this material to prevent splattering or staining of surfaces that are to be exposed after the Work is completed. Surfaces that are stained as a result of the Contractor's operation shall be repaired and/or replaced to the satisfaction of the Owner's representative at the Contractor's own expense.

F. Bituminous paving shall not be applied until the Owner's representative inspects and approves the finished base.

G. All existing paved surfaces to be overlaid must be thoroughly cleaned by a self-propelled sweeper. Areas inaccessible by power sweeper shall be broom swept until all non-pavement surface matter is removed.

3.3 APPLICATION

A. Tack Coat

1. Apply to contact surfaces of all Portland cement concrete surfaces and surfaces abutting or projecting into bituminous concrete pavement.
2. Apply tack coat to existing bituminous concrete surfaces at match points and where indicated on the drawings.
3. Apply at a minimum rate of 0.05 gallons per square yard of surface.
4. Allow tack coat to dry until at proper condition to receive paving.

3.4 BITUMINOUS CONCRETE PAVEMENT

A. Place bituminous concrete mixture on completed, compacted base surface, spread, and strike off.

B. Whenever possible, all pavements shall be spread by a self-propelled finishing machine. At inaccessible or irregular areas, pavement may be placed by hand methods. The hot mixture shall be spread uniformly to the required depth with hot shovels and rakes. After spreading, the hot mixture shall be carefully smoothed to remove all segregated course aggregate and rake marks. Rakes and lutes used for hand spreading shall be of the type designed for use on asphalt mixtures. Loads shall not be dumped faster than they can be properly spread. Workers shall not stand on the loose mixture while spreading.

C. Paving Machine Placement: Apply successive lifts of bituminous concrete in transverse directions with the surface course placed in the direction of surface-water flow. Place in typical strips not less than 10'-0" wide.

D. Joints: Make joints between old and new pavements, or between successive days' work, to ensure continuous bond between adjoining work. Construction joints shall have the same texture, density, and smoothness as other sections of bituminous concrete courses. Clean contact surfaces and apply tack coat.

3.5 ROLLING AND COMPACTION

A. The mixture, after being spread, shall be thoroughly compacted by rollers having a minimum weight of 240 pounds per inch of wheel width as soon as it will bear the weight of the rollers without undue displacement. The number, weight, and types of rollers and sequences of rolling operations shall be such that the required density and surface are consistently attained while the mixture is in a workable condition.

B. Compact mixture with hot hand tampers or hand rollers in areas inaccessible by self-propelled rollers.

C. Breakdown Rolling: Accomplish breakdown or initial rolling immediately following rolling of joints and outside edge. Check surface after breakdown rolling, and repair displaced areas by loosening and filling, if required, with hot material.

D. Second Rolling: Follow breakdown rolling as soon as possible, while mixture is hot. Continue second rolling until mixture has been thoroughly compacted.

E. Finish Rolling: Perform finish rolling while mixture is still warm enough for removal of roller marks. Continue rolling until roller marks are eliminated and course has attained maximum density.

F. Patching: Remove and replace paving areas mixed with foreign materials and defective areas and fill with fresh, hot bituminous concrete. Compact by rolling to maximum surface density and smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened. Erect barricades to protect paving from traffic until mixture has cooled enough not to be marked.

3.6 BITUMINOUS CONCRETE SIDEWALKS

A. Forms: Where walls, curbing, or other suitable permanent supports are not present, satisfactory forms shall be installed to assist in securing alignment and adequate compaction of the base and surface courses. All forms shall be removed and backfilled with proper material.

B. Placing Bituminous Concrete: The bituminous concrete walk surface shall be laid in a single course to a depth after compaction of 2 inches, unless otherwise detailed or directed. Unless otherwise directed, the walk shall have a maximum cross slope of two percent (2%) to provide for proper drainage.

1. Spreading Mixture. The mixture shall be dumped, as needed, in wheelbarrows or an approved steel dump sheet outside the areas on which it is to be placed. It shall then be immediately distributed into place by means of shovels and raked into a uniformly loose layer to the full width required and of such depth that, when the Work is completed, it shall conform to the grade and surface contour required.

2. Rolling. The surface shall be rolled with a self-propelled, tandem roller weighing not less than 1½ tons and not more than 5 tons. In places inaccessible to a power roller, compaction shall be obtained by means of mechanical rammers or by hand tampers weighing not less than 50 pounds and having a tamping face not exceeding 100 square inches.
3. Testing Surface. When tested with a 10-foot straightedge placed parallel to the centerline of the courses, there shall be no deviation from a true surface in excess of ¼ of an inch.

3.7 FIELD QUALITY CONTROL

A. Independent Testing Laboratory: If elected by the Owner, an independent testing laboratory shall be retained to perform construction testing of in-place bituminous concrete courses for compliance with requirements for thickness and surface smoothness. The Owner shall pay for costs of the testing. Bituminous surface and base courses shall be randomly cored at a minimum rate of one (1) core for every 20,000 square feet of paving. However, no less than three (3) cores in light duty areas and three cores in heavy duty areas shall be obtained. Coring holes shall be immediately filled with full-depth asphalt or with concrete. Bituminous concrete pavement samples shall be tested for conformance with the mix design.

B. Grade Control: Establish and maintain required lines and elevations.

C. Thickness: In-place compacted thickness shall not be less than the thickness specified on the drawings. Areas of deficient paving thickness shall receive a tack coat and a minimum 1-inch thickness, at the discretion of the Owner's representative, until specified thickness of the course is met or exceeded at no additional expense to the Owner.

D. Surface Smoothness: Testing shall be performed on the finished surface of each bituminous concrete course for smoothness, using 10-foot straightedge applied parallel with, and at right angles to centerline of paved area. The results of these tests shall be made available to the Owner's representative upon request. Surfaces will not be acceptable if exceeding following tolerances for smoothness:

1. Base Course Surface: ¼-inch.
2. Wearing Course Surface: 3/16-inch.

E. Check surfaces areas at intervals necessary to eliminate ponding areas. Remove and replace unacceptable paving as directed by the Owner's representative.

F. Compaction: Field density tests for in-place materials shall be performed by examination of field cores and shall have a minimum compacted density of ninety-five percent (95%) of laboratory Marshall Density in accordance with one (1) of the following standards:

1. Bulk Specific Gravity and Density of Compacted Bituminous Mixture Using Paraffin-Coated Specimens: ASTM D 1188-96.
2. Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface Dry Specimens: ASTM D 2726-04.
3. Rate of testing shall be one core per 20,000 square feet of pavement, with a minimum of three (3) cores from heavy-duty areas and three (3) cores from standard-duty areas. Cores shall be cut from areas representative of the project.
4. Areas of insufficient compaction shall be delineated, removed, and replaced in compliance with the specifications at no expense to the Owner.

3.8 MEETING EXISTING PAVEMENTS

A. Where new pavements are to meeting existing pavements, the Contractor shall saw cut the existing pavements so that there will be a vertical butting surface between the old and new pavements. Sawcutting of existing pavements shall be along neat, straight, and even lines, and shall be done in such a manner so as not to damage the adjacent pavement, which is to remain.

B. Full-Depth Pavement: The existing pavement shall be sawcut by an approved method for the full depth of the pavement prior to placement of any new pavement. The existing bituminous surface shall be trimmed to a neat true line with straight vertical edges free from irregularities, and the trimmed edges shall be treated with a light coating of asphaltic emulsion immediately prior to the installation of the new abutting bituminous concrete surface course to provide a bond between the old and new pavement. The new compacted pavement surface shall be finished flush with the adjacent pavement.

C. Bituminous Concrete Overlays: A line shall be cut by an approved method where the new pavement is to meet the existing pavement. The existing bituminous surface shall be trimmed to a neat true line with straight vertical edges free of irregularities for a minimum depth of 1½ inches. Sufficient pavement shall then be ground by machine method leaving a tapered Section of pavement ground 1½ inches thick at the pavement butt and feathered back to meet the existing pavement surfaces. The ground, tapered transition section width shall be 2 feet at driveways and 6 feet in roadways and parking areas. Immediately prior to the placement of the bituminous concrete overlay the trimmed edges of the existing pavement shall be treated with a coating of asphaltic emulsion to bond the new pavement to the old pavement. The new pavement surface shall be finished flush with the adjacent pavement. Surface seam of pavement joint shall be painted with emulsion and covered with sand or proper material to absorb excess emulsion.

END OF SECTION 321216

SECTION 321214 - SITE CAST-IN-PLACE CONCRETE

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 DESCRIPTION OF THE WORK

A. Provide all facilities, labor, materials, tools, equipment, appliances, transportation, supervision, and related work necessary to complete the Work specified in this section, and as shown on the Drawings.

B. The Work of this section includes site cast-in-place concrete, including but not necessarily limited to, concrete sidewalks, concrete driveway and pedestrian walkways, utility bases, concrete curbing, light pole bases, retaining walls, and thrust blocks.

1.3 RELATED SECTIONS

A. Carefully examine all the Contract Documents for requirements, which affect the Work in this section. Other specification sections, which directly relate to the Work of this section include, but are not limited to, the following:

1. Section 312000 “Earth Moving”

1.4 QUALITY ASSURANCE

A. Unless otherwise specified, work and materials for construction of concrete walks shall conform to ACI 316R. Other cast-in-place concrete shall conform to ACI 301.

B. Work, materials, and color of the handicap ramp paving shall conform to applicable sections of ADA and State Standards whichever is more restrictive. The maximum cross slope for sidewalks shall be two percent (2%) unless otherwise noted.

C. Paving work, base course, etc., shall be done only after excavation and construction work, which might injure them, has been completed. Damage caused during construction shall be repaired before acceptance.

D. Existing paving areas shall, if damaged or removed during course of this project, be replaced under this section of the specification. Workmanship and materials for such repair and replacement, except as otherwise noted, shall match as closely as possible those employed in existing work.

E. Pavement, base, or subbase shall not be placed on a muddy or frozen subgrade.

F. Dimensions, locations, and details of equipment pads, anchors, supports, and similar features indicated on the Drawings are approximate. Manufacturer’s approved shop drawings of equipment to be supported, anchored, or contained thereby shall be consulted for exact location, size, and details.

1.5 SUBMITTALS

A. For each type of specially furnished concrete provide a description of methods and the sequence of placement.

B. Submit manufacturer's product data for the following:

1. Form release agent.
2. CIP and surface mounted ADA approved detectable surface.
3. Preformed joint filler.

C. Submit samples of the following:

1. Preformed joint filler.

1.6 TESTING

A. The Owner will retain and pay for the services of a State approved laboratory to perform all concrete testing and inspections in accordance with applicable ASTM standards.

B. Tests will be required to determine whether the concrete being produced complies with the standard of quality and strength as specified.

C. Additional Tests: The Contractor may have the testing service make additional tests of in-place concrete when test results indicate that specified concrete strengths and other characteristics have not been attained. The testing inspection agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42-04 or such non-destructive testing methods that may be approved by the Owner's representative. Contractor shall pay for all such tests conducted. Any holes made shall be patched by the Contractor at their own expense.

D. Concrete Replacement: Failure of any test or to follow proper installation procedures will require that the concrete be removed and properly replaced by the Contractor at their own expense.

PART 2 - PRODUCTS

2.1 AGGREGATE BASE COURSE

A. Material for aggregate base course shall be well-graded, granular, free-draining gravel compacted to ninety-five percent (95%) of optimum density. Material shall have at least ninety-five percent (95%) passing a 1½-inch sieve and not more than eight percent (8%) passing a number 200 sieve.

2.2 STEEL REINFORCEMENT

A. Steel reinforcing bars shall conform to ASTM A 615.

1. Bars employed as reinforcement shall be the deformed type.
2. Bars employed as dowels shall be hot-rolled plain rounds.
3. Unless otherwise indicated on the Drawings, reinforcing bars shall be Grade 60.

B. Welded wire fabric reinforcement shall conform to the applicable requirements of ASTM A 185-02. Fabric reinforcement shall be furnished in flat sheets. Fabric reinforcement in rolls will not be permitted.

2.3 PORTLAND CEMENT CONCRETE

A. Portland cement concrete for pavements, walks, and slabs shall be the air-entrained type with a maximum water/cement ratio of 5.0 conforming to ACI 316R. Minimum compressive strength at twenty-eight (28) days shall be 4,000 psi. Other cast-in-place concrete shall have a minimum compressive strength of 3,000 psi at twenty-eight (28) days.

1. Concrete shall be the air-entrained type conforming to ASTM C 94. Air content by volume shall be six percent (6%) and shall be tested in accordance with ASTM C 231-04. No antifreeze or other admixtures are permitted.
2. Concrete slump shall be no less than 2 inches nor greater than 4 inches, determined in accordance with ASTM C 143.
3. Cement shall be Portland cement, conforming to ASTM C 150-04, Type I or II. Only one (1) color of cement, all the same manufacturer, shall be used for the Work. Type III cement shall be used only with the prior approval of the Owner's representative.
4. Fine and coarse aggregates shall conform to ASTM C 33-03.
5. Concrete shall contain a water reducing agent to minimize cement and water content of the concrete mix at the specified slump. Water reducing agent shall conform to ASTM C 494.
6. No calcium chloride or admixtures containing calcium chloride shall be added to the concrete. No admixtures other than those specified shall be used in the concrete without the specific written permission of the Owner's representative in each case.
7. The concrete mix shall be designed by a licensed Professional Engineer to meet project design conditions.
8. Retempering of concrete will not be allowed.
9. Use latex or acrylic bonding agents when placing new concrete against existing concrete.

2.4 CURING MATERIALS FOR UNCOLORED CONCRETE

A. Curing shall be by moist curing (preferred) or by use of curing compound.

B. Curing paper shall be non-staining, fiber reinforced laminated Kraft bituminous product conforming to ASTM C 171-03. 4-mil polyethylene sheeting may be substituted for curing paper.

C. Curing compound shall be a resin-base, white pigmented compound conforming to ASTM C 309-03, Type 2.

D. Sodium Silicate curing compounds shall be used where required by the weather, approved construction schedules and construction that is not adaptable to damp curing.

E. Curing compounds shall contain a fugitive dye or when hot weather conditions dictate, a fugitive heat reflecting pigment.

2.5 EXPANSION JOINTS

A. Expansion joint filler shall be preformed, non-bituminous type joint filler conforming to ASTM D 1752-04a, or preformed, bituminous type joint filler conforming to D 1751-04.

1. Premolded filler shall be one (1) piece for the full depth and width of the joint leaving a sealant recess as indicated.
2. Use of multiple pieces of lesser dimensions to make up required depth and width of joint will not be permitted.
3. Except as otherwise noted on the Drawings, joint filler shall be ½-inch-thick.

B. Expansion joints shall receive joint backer rod and shall be sealed with joint sealant.

2.6 BOND BREAKER

A. Bond breaker shall be asphalt felt conforming to ASTM D 2626-04, Type I or 6-mil polyethylene sheeting.

2.7 FORMS

A. Cylindrical Forms: Sonotube **Fibre Forms**, wax-impregnated strippable forms or ABS or PVC plastic reusable forms.

B. Forms for Exposed Finish: Plywood, metal, metal-framed plywood faced, or other acceptable panel materials. Plywood shall be APA Ref. 1 B-B (Concrete Form), Class I Exterior Grade plywood or B-B or A-C Class I high density overlay concrete form plywood. Form work materials shall produce smooth, continuous, straight, and level surfaces.

C. Forms for Unexposed Finish: Plywood, lumber, or metal, with lumber dressed on at least two (2) edges and one (1) side.

D. Form Ties: Provide prefabricated, adjustable length galvanized steel snap-off ties, with brackets, cones, cornerlocks, and other accessories, as necessary.

E. Form Release Agent: Commercial formulation compounds that will not bond with, stain, or adversely affect concrete.

F. Forms shall be true to line and free from warp, and shall be of sufficient strength, when staked, to resist the pressure of the concrete without springing. Form work shall be designed so that sections may be fastened together to prevent vertical or horizontal movement of ends.

PART 3 - EXECUTION

3.1 GENERAL

A. All permanent sidewalks shall be poured concrete. If temporary walks are required, bituminous concrete may be used.

B. No concrete walks shall be poured after 12 noon unless a guard is visibly stationed nearby to prevent graffiti. The Contractor shall be responsible for replacing any sidewalk with graffiti if he/she fails to provide adequate protection from graffiti.

C. The Owner’s standard for sidewalk is 5 feet wide, unless otherwise shown or noted on the drawings, constructed of 4000 psi air entrained concrete reinforced with 6 x 6 – #6 welded, plain, cold-drawn steel wire fabric. Walk surface shall have a fine broom or float finish. The thickness of the walk shall be a minimum of 4-inches, on an 8-inch-thick compacted gravel base.

D. Where sidewalks intersect, the Contractor shall provide a 3’-6” radius at the intersection corners.

3.2 PREPARATION OF SUBGRADE

A. Areas to be paved will be compacted and brought to subgrade elevation under Section 312000 “Earth Moving”, before work of this section is performed. Final fine grading, and compaction of areas to receive paving, as required to form a firm, uniform, accurate and unyielding subgrade at required elevations and to required lines, shall be done under this Section.

B. Existing subgrade material, which will not readily compact as required, shall be removed and replaced with satisfactory materials. Additional materials needed to bring subgrade to required line and grade and to replace unsuitable material removed shall be material conforming to this Section.

C. Subgrade of areas to be paved shall be recompacted as required to bring the top 8 inches of material, immediately below the gravel base course, to a compaction at optimum moisture of at least ninety-five percent (95%) of maximum density, as determined by ASTM D 1557-02. Subgrade compaction shall extend for a distance of at least 1-foot beyond pavement edge.

D. Excavation required in pavement subgrade shall be completed before fine grading and final compaction of subgrade are performed. Where excavation must be performed in completed subgrade, subbase, base, or pavement, subsequent backfill and compaction shall be performed as directed by the Owner's representative and as specified in Section 312000 "Earth Moving". Completed subgrade, after filling such areas, shall be uniformly and properly graded.

E. Areas being graded or compacted shall be kept shaped and drained during construction. Ruts greater than, or equal to, 2 inches deep in subgrade, shall be graded out, reshaped as required, and recompacted before placing pavement.

F. Materials shall not be stored or stockpiled on subgrade.

G. Disposal of debris and other material excavated under this section, and material unsuitable for, or in excess of requirements for, completing work of this section shall be disposed of off-site.

H. Prepared subgrade shall be inspected and approved by the Owner's representative before installation of the gravel base course. Disturbance to subgrade caused by inspection procedures shall be repaired under this Section of the Specification.

3.3 AGGREGATE BASE COURSE

A. Aggregate base course for concrete paving and the spreading, grading, and compaction methods employed shall conform to the standard requirements for usual base course of this type for first class roadwork.

B. Width of base course shall be greater than or equal to the width of pavement surface, if continuous lateral support is provided during rolling. The width of base course shall extend at least two (2) times base thickness beyond the edge of the course above, if it is not so supported.

C. Aggregate shall be applied in lifts less than or equal to 6 inches thick, compacted measure. Each lift shall be separately compacted to specified density.

1. Material shall be placed adjacent to wall, manhole, catch basin, and other structures only after they have been set to required grade and level.
2. Rolling shall begin at the sides and progress to the center of crowned areas and shall begin on the low side and progress toward the high side of sloped areas. Rolling shall continue until material does not creep or wave ahead of roller wheels.
3. Surface irregularities, which exceed ½-inch, as measured by means of a 10-foot-long straightedge, shall be replaced and properly recompacted.

D. Base course shall be compacted at optimum moisture content to not less than ninety-five percent (95%) of maximum density as determined by ASTM D 1557-02.

E. Subgrade and base course shall be kept clean and uncontaminated. Less select materials shall not be permitted to become mixed with gravel. Materials spilled outside pavement lines shall be removed and the area repaired.

F. Portions of subgrade, or of construction above, which become contaminated, softened, or dislodged by the passing of traffic, or otherwise injured, shall be cleaned, replaced, or otherwise repaired to conform to the requirements of this specification before proceeding with the next operation.

3.4 STEEL REINFORCEMENT

A. Before being placed in position, reinforcing for reinforced concrete shall be thoroughly cleaned of loose mill and rust scale, dirt, ice, and other foreign material, which may reduce the bond between the concrete and reinforcing. Where there is a delay in placing concrete after reinforcement is in place, bars shall be reinspected and cleaned when necessary.

B. Any bar showing cracks after bending shall be discarded.

C. Unless otherwise indicated on the Drawings, reinforcing shall extend within 2 inches of formwork and expansion joints. Reinforcing shall continue through control joints. Adjacent sheets of fabric reinforcing shall lap 6 inches.

D. After forms have been coated with form release agents, but before concrete is placed, reinforcing steel anchors shall be securely wired in the exact position called for, and shall be maintained in that position until concrete is placed and compacted. Chair bars and supports shall be provided in a number and arrangement satisfactory to the Owner’s representative.

E. Welded wire fabric and reinforcing bars shall be elevated off gravel base by use of metal chair supports or approved equal.

3.5 CONCRETE PAVING

A. Paving mix, equipment, methods of mixing and placing, and precautions to be observed as to weather, condition of base etc., shall meet the requirements of ACI 316R. Pavement shall be constructed in accordance with the Drawings.

B. The Owner’s representative shall be notified of concrete placement sufficiently in advance of start of operation to allow their representative to complete preliminary inspection of the Work, including subgrade, forms, and reinforcing steel, if used.

C. Normal concrete placement procedures shall be followed. Concrete shall arrive at the job site in a timely manner so that no additional water will be required to produce the desired slump. When conditions develop that require the addition of water to produce the desired slump, permission of the Owner’s representative must be obtained. The concrete shall be transported from the mixer to its place of deposit by a method that will prevent segregation or loss of material.

D. Work shall not be performed during rainy weather or when temperature is less than 40°F (4.4°C).

E. Adjacent work, etc., shall be protected from stain and damage during entire operation. Damaged and stained areas shall be replaced or repaired to equal their original conditions.

F. Existing concrete, earth, and other water-permeable material against which new concrete is to be placed shall be thoroughly damp when concrete is placed. There shall be no free water on surface.

G. Concrete, which has set, or partially set before placement shall not be employed. Retempering of concrete will not be permitted.

H. Concrete shall be thoroughly spaded and tamped to secure a solid and homogeneous mass, thoroughly worked around reinforcement and into corners of forms.

3.6 PLACING CAST-IN-PLACE CONCRETE

A. Before placing concrete, forms and the space to be occupied by the concrete shall be thoroughly cleaned and reinforcing steel and embedded metal shall be free from dirt, oil, mill scale, loose rust, paint, and other material which might tend to reduce bond.

B. Existing concrete, earth, and other water-permeable material against which new concrete is to be placed and shall be thoroughly damp when concrete is placed. There shall be no free water on the surface.

C. Concrete, which has set, or partially set, before placement shall not be employed.

D. Concrete shall be thoroughly spaded and tamped to secure a solid and homogeneous mass, thoroughly worked around reinforcement and into corners of forms.

E. When joining fresh concrete to concrete which has attained full set, the latter shall be cleaned of foreign matter, and mortar scum and laitance shall be removed by chipping and washing. Clean, roughened base surface shall be saturated with water, but shall have no free water on surface. A coat of 1:1 cement-sand grout, approximately 1/8-inch-thick shall be well scrubbed into thoroughly dampened concrete base. New concrete shall be placed immediately, before grout has dried or set.

3.7 FINISHING

A. Concrete flatwork surfaces shall be screened off and finished true to line and grade, and free of hollows and bumps. Surface shall be dense, smooth, and at exact level and slope required.

1. Finished concrete surface for concrete subbase shall be woodfloated to a slightly rough surface. Surface shall not deviate more than ¼-inch in 10 feet.
2. Finished concrete surface for concrete pavement, walks, and pads shall be wood-floated and steel troweled to a smooth surface. Surface shall not deviate more than 1/8-inch in 10 feet.

B. Unless otherwise indicated, horizontal surfaces of concrete surfaces, which will be exposed, shall be given a light broomed finish, with direction of grooves in concrete surface perpendicular to length of concrete band, slab, or pad. After concrete has set sufficiently to prevent coarse aggregate from being torn from the surface, but before it has completely set, brooms shall be drawn across it to produce a pattern of small parallel grooves. Broomed surface shall be uniform, with no smooth, unduly rough or porous spots, or other irregularities. Coarse aggregate shall not be dislodged by the brooming operation.

C. Immediately following finishing operations, arises at edges and both sides of expansion joints shall be rounded to a ¼-inch radius. Control joints to be tooled shall be scored into slab surface with scoring tool. Adjacent edges of control joint shall be same time be finished to a ¼-inch radius.

D. Where finishing is performed before the end of the curing period, concrete shall not be permitted to dry out, and shall be kept continuously moist from time of placing until end of curing period, or until curing membrane is applied.

3.8 CURING

A. It is essential that concrete be kept continuously damp from time of placement until the end of the specified curing period. It is equally essential that water not be added to the surface during floating and troweling operations, and not earlier than 24 hours after concrete placement. Between finishing operations, the surface shall be protected from rapid drying by a covering of waterproofing paper. Surface shall be damp when the covering is placed over it and shall be kept damp by means of a good spray of water, applied as often as necessary to prevent drying, but not sooner than 24 hours after placing concrete. None of the water so applied shall be troweled or floated into the surface.

B. Concrete surfaces shall be cured by completely covering them with curing paper or an application of a curing compound.

1. Concrete cured using waterproof paper shall be completely covered with paper with seams lapped and sealed with tape. Concrete surface shall not be allowed to become moistened between 24 and 36 hours after placing concrete. During curing period surface shall be checked frequently and sprayed with water as often as necessary to prevent drying, but not earlier than 24 hours after placing concrete.
2. If concrete is cured with a curing compound, the compound shall be applied at a rate of 200 square feet per gallon, in two (2) applications perpendicular to each other.
3. Curing period shall be seven (7) days minimum.

C. Only if additional protection is absolutely required, the surface should remain uncovered for at least four (4) days, after which time new and unwrinkled non-staining reinforced waterproof Kraft curing paper may be used.

3.9 HANDICAP RAMPS

A. Paving mix, equipment, methods of mixing and placing, and precautions to be observed as to weather, condition of base etc., shall meet the requirements of ACI 316R for any concrete paving in similar conditions. Handicap ramps shall be constructed in accordance with the Drawings, and ADA Guidelines 4.7.10 and 4.29.2, as amended. The maximum cross slope for sidewalks shall be two percent (2%) unless otherwise noted.

B. Normal concrete placement procedures shall be followed. Concrete shall arrive at the job site in a timely manner so that no additional water will be required to produce the desired slump. When conditions develop that require the addition of water to produce the desired slump, permission of the Owner’s representative must be obtained. The concrete shall be transported from the mixer to its place of deposit by a method that will prevent segregation or loss of material.

3.10 EXPANSION JOINTS

A. Expansion joints shall be ½-inch-wide and shall be as located on the Drawings. Expansion joint shall be troweled in the concrete to required width with preformed joint filler in place. Joint filler shall extend the full depth of the slab. Joint filler shall extend the full length of the expansion joint.

1. For concrete walks, pavements, and pads, depth of joint filler shall be as required to form a 1¼-inch-deep sealant and back rod recess below finished concrete surface.

3.11 CONTROL JOINTS

A. Unless otherwise indicated, control joints shall be tooled into the concrete slab, with 3-inch-wide border and toweled edges, in the pattern indicated on the Drawings, or every 10-foot o.c. maximum. Joint shall be made after concrete is finished and when the surface is stiff enough to support the weight of workmen without damage to the slab, but before the slab has achieved its final set.

B. Scoring shall cut into slab surfaces at least 1-inch, but in no case not less than twenty-five percent (25%) of slab depth.

3.12 COLD WEATHER CONCRETING

A. Materials for concrete shall be heated for concrete, which is mixed, placed, or cured when the mean daily temperature is below 40°F or is expected to fall below 40°F within 72 hours. The concrete, after placement, shall be protected by covering, heat, or both.

B. Details of handling and protecting concrete during freezing weather shall be subject to the approval and direction of the Owner's representative. Procedures shall be in accordance with provisions of ACI 306R.

3.13 HOT WEATHER CONCRETING

A. Concrete just placed shall be protected from the direct rays of the sun and the forms and reinforcement just prior to placement shall be sprinkled with cold water. Every effort shall be made to minimize delays that will result in excessive mixing of the concrete after arrival on the job.

B. During periods of excessively hot weather (95°F, or above), ingredients in the concrete shall be cooled insofar as possible and cold mixing water shall be used to maintain the temperature of the concrete at permissible levels all in accordance with the provisions of ACI 305R-99. Any concrete with a temperature below 95°F, when ready for placement, will not be acceptable, and will be rejected.

C. Temperature records shall be maintained throughout the period of hot weather giving air temperature, general weather conditions (calm, windy, clear, cloudy, etc.) and relative humidity. Records shall include checks on temperature of concrete as delivered and after placing in forms. Data should be correlated with the progress of the Work so that conditions surrounding the construction of any part of the structure can be ascertained.

3.14 PROTECTION OF CONCRETE SURFACES

A. Concrete surface shall be protected from traffic or damage until surfaces have hardened sufficiently. If necessary, ½-inch-thick plywood sheets shall be used to protect the exposed surface.

END OF SECTION 321314

SECTION 321723 - PAVEMENT MARKINGS

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. Description of The Work

1. Provide all facilities, labor, materials, tools, equipment, appliances, transportation, supervision, and related work necessary to complete the Work specified in this section, and as shown on the Drawings.
2. The Work under this section includes the application of pavement markings as indicated on the Drawings and as specified herein.

B. Related Sections

1. Carefully examine all the Contract Documents for requirements that affect the Work in this section. Other specification sections, which directly relate to the Work of this section include, but are not limited to, the following:

a. Section 320000 “Curbing”
b. Section 321216 “Asphalt Paving”

1.3 PROJECT CONDITIONS

A. Maintain access for vehicular and pedestrian traffic as required for other construction activities. Utilize flagmen, barricades, warning signs, and warning lights as required.

1.4 SUBMITTALS

A. Submit material certificate to the Owner’s representative signed by the material producer and Contractor, certifying that materials comply with these specifications and have been approved for use by the State of Connecticut Department of Transportation.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Pavement markings shall conform to Connecticut DOT Form 816, Section 12.09 and Articles M.07.20, M.07.21, and M.07.30 and the Manual of Uniform Traffic Control Devices, current edition.

B. Traffic markings shall be white, yellow, and blue traffic paint, as indicated on the Drawings.

PART 3 - EXECUTION

3.1 APPLICATION

A. The material shall be applied to the pavement by equipment used specifically for the application of pavement markings and shall be of a standard commercial manufacturer.

B. The Contractor shall provide survey control for layout of pavement markings by utilizing his own surveyor or hiring a registered land surveyor. The cost of this survey control shall be included in the cost of the work.

C. Markings shall be applied at a minimum thickness of 15 ±1 mil.

D. Pavement striping and marking shall be applied in accordance with this Specification and the Drawings. See Drawings for layout and additional notes. No paint shall be applied to new pavement until the top pavement course has cured at least one (1) week minimum and allow two (2) weeks curing period on newly installed bituminous concrete lip curbing.

E. Stripe all stalls on new pavement as shown on the Drawings accurately, and paint all parking stall striping in white 4-inch-wide strips. All lines shall be straight with sharp corners and clean edges. Where they occur, directional arrows, cross hatching, lane divider strips, stop lines, and lettering shall be painted white to the size, length, and spacing as specified and indicated on the Drawings.

F. All stripes shall be applied one (1) coat with brush, spray, or marking machine over dry clean pavement surfaces, when the atmospheric temperature is at or above 40°F and when the weather is otherwise favorable in the opinion of the Owner's representative.

G. Furnish only skilled workmen who are experienced and normally employed in the Work of installing traffic lines. Supply all the necessary equipment and materials for the installation of the traffic lines.

H. The Contractor shall be responsible for cleaning the pavement of dust, dirt, old pavement markings, concrete curing compounds, and other foreign material, which may be detrimental to the adhesion of the paint film.

I. All stalls shown on the plan are to be striped in accordance with the details. The line between rows of stalls shall be a single line.

J. Where entire areas are to be crosshatched, the striping shall conform to the cross-hatching described in the Drawings.

K. The Contractor shall clean and sweep all areas to be striped or restriped of all sand, dirt, grease, oil, etc., as required so as to produce a first-class job. By proceeding, the striping subcontractor agrees the surface is satisfactory to produce the required first-class job and warrant the one (1) year guarantee described.

L. The Contractor shall protect the buildings, walks, pavement, curbing, trees, shrubs, mulch, etc. from over-spray of paint and damage by his operations.

M. Traffic shall not be permitted on the pavement until the paint is thoroughly dry.

3.2 PAVEMENT MARKING REMOVAL

A. Pavement Markings shall be removed to the fullest extent possible by an approved method. Pavement markings shall be removed before any change is made in the traffic pattern. Any damage to the pavement or surfacing caused by pavement marking removal shall be repaired by the Contractor at their expense by methods acceptable to the Owner's representative.

B. Approved methods include, but are not limited to:

1. Sand blasting using air or water.
2. High pressure water.
3. Steam or superheated water.
4. Mechanical devices such as grinders, sanders, scrapers, scarifiers, and wire brushers.

C. Painting over a pavement marking line by use of asphaltic liquids or paints will not be permitted, unless otherwise approved by the Owner's representative.

D. Material deposited on the pavement as a result of removing markings shall be removed as the Work progresses. Accumulations of sand or other material which might interfere with drainage or could constitute a hazard to traffic will not be permitted.

E. Where blast cleaning is used for the removal of pavement markings and such removal operation is being performed within 10 feet of a lane occupied by traffic, the residue including dust shall be removed immediately after contact between the sand and the surface being treated. Such removal shall be by a vacuum attachment operating concurrently with the blast cleaning operation, or by other methods approved by the Owner's representative.

END OF SECTION 321723

SECTION 321726 - TACTILE WARNING 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. Cast-in-place detectable warning tiles.

B. Related Requirements:

1. Section 321314 "Site Cast-in-Place Concrete" for concrete walkways serving as substrates for tactile warning surfacing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples for Initial Selection: For each type of exposed finish requiring color selection.

C. Samples for Verification: For each type of tactile warning surface, in manufacturer's standard sizes unless otherwise indicated, showing edge condition, truncated-dome pattern, texture, color, and cross section; with fasteners and anchors.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For tactile warning surfacing, to include in maintenance manuals.

1.5 PROJECT CONDITIONS

A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.

B. Weather Limitations for Mortar and Grout:

1. Cold-Weather Requirements: Comply with cold-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602.
2. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602. Provide artificial shade and windbreaks, and use cooled materials as required. Do not apply mortar to substrates with temperatures of 100 deg F and higher.

a. When ambient temperature exceeds 100 deg F, or when wind velocity exceeds 8 mph and ambient temperature exceeds 90 deg F, set unit pavers within 1 minute of spreading setting-bed mortar.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of tactile warning surfaces that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Deterioration of finishes beyond normal weathering and wear.
b. Separation or delamination of materials and components.

2. Warranty Period: Five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 TACTILE WARNING SURFACING, GENERAL

A. Accessibility Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines for Buildings and Facilities and ICC A117.1 for tactile warning surfaces.

1. For tactile warning surfaces composed of multiple units, provide units that when installed provide consistent side-to-side and end-to-end dome spacing that complies with requirements.

B. Source Limitations: Obtain each type of tactile warning surfacing from single source with resources to provide materials and products of consistent quality in appearance and physical properties.

2.2 DETECTABLE WARNING TILES

A. Cast-in-Place Detectable Warning Tiles: Accessible truncated-dome detectable warning tiles configured for setting flush in new concrete walkway surfaces, with slip-resistant surface treatment on domes and field of tile.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Armor-Tile; **Cast-in-Place** (Basis of Design)
b. ADA Solutions, Inc.; **Cast-in-Place**
c. Detectable Warning Systems; **EZ Set Tile Cast-in-Place**

2. Material: Cast-fiber-reinforced polymer concrete tile.
3. Color: As selected by Architect and Owner from manufacturer's full line.
4. Shapes and Sizes:

a. Rectangular panel: 24 inches by 48 inches

5. Dome Spacing and Configuration: Manufacturer's standard compliant spacing, in rectangular pattern.
6. Mounting:

a. Permanently embedded detectable warning tile wet-set into freshly poured concrete.

2.3 ACCESSORIES

A. Fasteners and Anchors: Manufacturer's standard as required for secure anchorage of tactile warning surfaces, noncorrosive and compatible with each material joined, and complying with the following:

1. Furnish Type 316 stainless-steel fasteners for exterior use.
2. Fastener Heads: For nonstructural connections, use flathead or oval countersunk screws and bolts with tamper-resistant heads, colored to match tile.

B. Sealant: As recommended by manufacturer for sealing perimeter of tactile warning surfacing unit.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that pavement is in suitable condition to begin installation according to manufacturer's written instructions. Verify that installation of tactile warning surfacing will comply with accessibility requirements upon completion.

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

3.2 INSTALLATION OF TACTILE WARNING SURFACING

A. General: Prepare substrate and install tactile warning surfacing according to manufacturer's written instructions unless otherwise indicated.

B. Place tactile warning surfacing units in dimensions and orientation indicated. Comply with location requirements of AASHTO MP 12.

3.3 INSTALLATION OF DETECTABLE WARNING TILES

A. Cast-in-Place Detectable Warning Tiles:

1. Concrete Paving Installation: Comply with installation requirements in Section 321314 "Site Cast-in-Place Concrete." Mix, place, and finish concrete to conditions complying with detectable warning tile manufacturer's written requirements for satisfactory embedment of tile.
2. Set each detectable warning tile accurately and firmly in place and completely seat tile back and embedments in wet concrete by tamping or vibrating. If necessary, temporarily apply weight to tiles to ensure full contact with concrete.
3. Set surface of tile flush with surrounding concrete and adjacent tiles, with variations between tiles and between concrete and tiles not exceeding plus or minus 1/8-inch from flush.
4. Protect exposed surfaces of installed tiles from contact with wet concrete. Complete finishing of concrete paving surrounding tiles. Remove concrete from tile surfaces.
5. Clean tiles using methods recommended in writing by manufacturer.

3.4 CLEANING AND PROTECTION

A. Remove and replace tactile warning surfacing that is broken or damaged or does not comply with requirements in this Section. Remove in complete sections from joint to joint unless

otherwise approved by Architect. Replace using tactile warning surfacing installation methods acceptable to Architect.

B. Protect tactile warning surfacing from damage and maintain free of stains, discoloration, dirt, and other foreign material.

END OF SECTION 321726

SECTION 323110 - CHAIN LINK FENCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF THE WORK

A. Furnishing and installing woven wire fencing of the type and height specified and supported by metal posts erected where indicated on the Drawings and as specified herein.

B. Contractor shall coordinate work between all subcontractors, sections, and trades required for the proper completion of the work.

C. Contractor shall be responsible for the health and safety of all Contractor and Subcontractor workers during progress of the work.

1.3 REFERENCES

A. American Society for Testing and Materials (ASTM), latest revision.

1. ASTM A 90 – Standard Test Method for Weight (Mass) of Coating on Iron or Steel Articles with Zinc or Zinc Alloy.
2. ASTM A 123 – Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products.
3. ASTM A 153 – Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware.
4. ASTM A 392 – Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.
5. ASTM A 428 – Standard Test Method for Weight (Mass) of Coating on Aluminum-Coated Iron or Steel Articles.
6. ASTM A 491 – Standard Specification for Aluminum Coated Steel Chain Link Fence Fabric.
7. ASTM A 817 – Standard Specification for Metallic-Coated Steel Wire for Chain Link Fence Fabric and Marcelled Tension Wire.
8. ASTM A 824 – Standard Specification Metallic-Coated Steel Marcelled Tension Wire for Use with Chain Link Fence.
9. ASTM B 211 – Standard Specification for Aluminum and Aluminum-Alloy Bar, Rod, and Wire.
10. ASTM C 94 – Standard Specification for Ready-Mixed Concrete.
11. ASTM F 567 – Standard Practice for Installation of Chain Link Fence.
12. ASTM F 626 – Standard Specification for Fence Fittings.
13. ASTM F 900 – Standard Specification for Industrial and Commercial Swing Gates.
14. ASTM F 1043 – Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework.
15. ASTM F 1083 – Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.
16. ASTM F 1183 – Standard Specification for Aluminum Alloy Chain Link Fence Fabric.

B. Chain Link Fence Manufacturer’s Institute

1. Chain Link Fence Manufacturer’s Institute Product Manual, latest revision.

1.4 SUBMITTALS

A. Shop drawings showing the plan layout, spacing of components, post foundation dimensions, hardware anchorage, gates, and a schedule of components.

B. Material certificates or other data indicating compliance with these specifications for fabric, posts, fittings, hardware, and accessories.

C. Fence sample complete with all typical hardware and components. The samples shall be representative of the type of construction for the project and color of all components.

1.5 QUALITY ASSURANCE

A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

B. Supply material in accordance with Chain Link Fence Manufacturer's Institute Product Manual and this Specification.

C. Perform installation in accordance with ASTM F 567.

D. Maintain all facilities installed under this Section in proper and safe condition throughout the progress of the work.

1.6 PRODUCT HANDLING

A. Deliver fence fabric and accessories in packed cartons or firmly tied rolls.

B. Packages shall be labeled with the manufacturer's name.

C. Store fence fabric and accessories in a secure and dry place.

PART 2 - PRODUCTS

2.1 GENERAL

A. Material furnished shall be in good condition and shall not have been painted.

B. All posts and rails shall be straight, true to section and of sufficient length for proper installation.

C. Unless otherwise specified, hardware and accessories shall conform to the requirements of ASTM F 626 and ASTM A 123 or ASTM A 153 as applicable for zinc-coating.

2.2 LINE POSTS

A. Type I: 2-inch nominal (2.375 O.D.) steel pipe, 3.65 lb./lf, hot dipped galvanized, ASTM F 1083, with average zinc coating of 1.8 oz./ft^2 interior/exterior conforming to ASTM F 1043.

B. Type II: 2-inch nominal (2.375 O.D.) steel pipe, 3.12 lb./lf, cold formed and welded per ASTM F 1043, Group IC, minimal yield Strength 50,000 psi. External zinc coating shall be Type B, zinc with polymer film, 0.90 oz./ft^2. Internal coating shall be Type B, zinc 0.90 oz./ft^2 minimum, or type D, zinc pigmented, eighty-one percent (81%) nominal coating with 0.30 mils minimum thickness.

2.3 CORNER, END, AND PULL POSTS

A. Type I: 2.5-inch nominal (2.875 O.D.) steel pipe, 5.79 lb./lf, hot dipped galvanized, ASTM F 1083, with average zinc coating of 1.8 oz./ft^2 interior/exterior conforming to ASTM F 1043.

B. Type II: 2.5-inch nominal (2.875 O.D.) steel pipe, 4.64 lb./lf. External zinc coating shall be Type B, zinc with polymer film, 0.90 oz./ft^2. Internal coating shall be Type B, zinc 0.90 oz./ft^2 minimum, or type D, zinc pigmented, eighty-one percent (81%) nominal coating with 0.30 mils minim thickness.

2.4 BRACE ASSEMBLY

A. Rails

1. Type I: 1.25-inch nominal (1.660 O.D.) steel pipe, 2.27 lb./lf, hot dipped galvanized, ASTM F 1083, with average zinc coating of 1.8 oz./ft^2 interior/exterior conforming to ASTM F 1043.
2. Type II: 1.25-inch nominal (1.660 O.D.) steel pipe, 1.83 lb./lf. External zinc coating shall be Type B, zinc with polymer film, 0.90 oz./ft^2. Internal coating shall be Type B, zinc 0.90 oz./ft^2 minimum, or type D, zinc pigmented, eighty-one percent (81%) nominal coating with 0.30 mils minim thickness.

B. Truss rod shall be 3/8-inch zinc-coated steel with adjustable turnbuckles or truss tightener.

2.5 FABRIC

A. Wire fencing fabric shall be No. 9 gauge wire woven into a 1-12-inch diamond wire mesh, 6-foot height. Fabric shall be knuckled at bottom selvage, twisted at top selvage.

1. Zinc-Coated Steel Fabric: ASTM A 392, Class I, zinc-coated steel wire with minimum coating weight of 1.2 oz./ft^2 uncoated wire surface.
2. Aluminum-Coated Steel Fabric: ASTM A 491, coated by the hot-dip process before weaving. Minimum aluminum coating shall not be less than 0.40 oz./ft^2 of uncoated wire surface.
3. Aluminum Alloy Fabric: ASTM F 1183.

2.6 STRETCHER BARS

A. Bars shall be one-piece lengths of zinc-coated steel, not less than 2 inches shorter than the full height of the fencing fabric with a minimum cross section of 3/16-inch by ¾-inch in accordance with ASTM F 626.

2.7 TENSION WIRE

A. Marcelled (spiraled or crimped) No. 7 gauge, (0.177-inches) diameter, ASTM A 824. Tension wire coating shall conform to ASTM A 824 Type I, aluminum coated, 0.40 oz./ft^2 or Type II zinc-coated Class 2, 1.2 oz./ft^2.

2.8 HARDWARE AND TIES

A. Miscellaneous hardware, including but not limited to nuts, bolts, washers, clips, bands, rail ends, brackets, and straps shall be provided as required, hot-dip galvanized steel or aluminum alloy, ASTM F 626.

B. Tension bands shall be formed from flat or beveled steel and shall have a minimum thickness after galvanizing of 0.078 inches and a minimum width of ¾-inch.

C. Brace bands shall be formed from flat or beveled steel and shall have a minimum thickness after galvanizing of 0.108 inches and a minimum width of ¾-inch.

D. Wire ties shall be minimum 16-gauge galvanized steel wire or minimum 9-gauge aluminum alloy wire.

2.9 GATES

A. Gate Construction: ASTM F 900. Corners welded or assembled with special malleable or pressed-steel fittings and rivets or bolts to provide rigid connections.

B. Gate Posts:

1. Type I: 2.5-inch nominal (2.875 O.D.) steel pipe, 5.79 lb./lf, hot dipped galvanized, ASTM F 1083, with average zinc coating of 1.8 oz./ft^2 interior/exterior conforming to ASTM F 1043.
2. Type II: 2.5-inch nominal (2.875 O.D.) steel pipe, 4.64 lb./lf. External zinc coating shall be Type B, zinc with polymer film, 0.90 oz./ft^2. Internal coating shall be Type B, zinc 0.90 oz./ft^2 minimum, or type D, zinc pigmented, eighty-one percent (81%) nominal coating with 0.30 mils minim thickness.

C. Gate Frame: Constructed of minimum 1.25-inch nominal (1.660 O.D.) steel pipe, 1.83 lb./lf.

D. Wire Fencing Fabric: Fabric shall match that of fence, attached securely to frame at intervals not exceeding 15-inches.

E. Gate Leaves: Configured with intermediate members and diagonal truss rods or tubular members as necessary to provide rigid construction, free from sag or twist.

F. Hinges: Malleable iron, forged steel, or pressed steel to suit gate size, no-lift-off type, offset to permit 180-degree opening.

G. Provide minimum ½-inch-diameter drop rod on each gate pair. Drop rod assembly and related latches shall be configured to secure gate in a closed position and accept padlock as an integral part of the latch system.

H. Hinges, Stops, Keepers, and other hardware items shall be furnished as required for proper operation.

I. Locks:
1. Basis-of-Design Product: Locinox, LUKY J5.
2. Adaptor Plate for Lock: Locinox 3019LA.
3. Surface Mounted Strike: Locinox SAKL, requires a latch gap of 1-1/4-inches.
4. Adaptor Plate for Lock: Locinox 3018LA.
5. Tension Bar to Hold Chain Link around Mounted Lock: Locinox CLH-LA.
6. Hinge and Closer Assembly: Locinox TIGER (for gates up to 4-feet wide, 165 pounds. Hinge gap adjustable from 7/16-inchs to 1-inch.
7. Chain Link Bracket: Locinox CLB-TIGER.

2.12 CONCRETE

A. Concrete shall conform to ASTM C 94; or pre-packaged concrete mix, ASTM C 387. Minimum 28-day compressive strength of 3000 psi.

PART 3 - EXECUTION

3.1 GENERAL

A. Install fence with properly trained crew as shown on the drawings in accordance with ASTM F 567.

B. Install all nuts for tension bands and hardware bolts on the side of the fence opposite the fabric.

3.2 POSTS

A. Posts shall be spaced in line not further than 10 feet on centers.

B. Intermediate or line posts, except where indicated on the Drawings, may be driven by mechanical means. A suitable driving cap shall be used to ensure that no damage is caused to the post. Posts not driven, and all other type posts, shall be set in concrete conforming to the requirements herein and as shown on the Drawings.

C. Concrete post footings shall have a plan diameter 12-inches greater than the post diameter. Holes shall be clean and free of loose soil and debris. Concrete shall be placed continuously in one (1) operation and tamped or vibrated for consolidation. Lower limit of concrete footing shall be at least 4 inches below the bottom of the post. Tops of the concrete footings shall be crowned to shed water.

1. Line posts or line-post footings shall be installed a minimum of 36 inches below grade.
2. Corner, gate, and terminal post footings shall be installed a minimum of 42 inches below grade.

D. All corner, end posts, and gate posts shall be braced.

1. Brace each gate and corner post to adjacent line post with horizontal center brace rail and diagonal truss rods. Install brace rail one (1) bay from end and gate posts.
2. Corner and terminal posts are to be braced horizontally and diagonally. The braces are to extend over one (1) adjacent panel. Changes in line of 30 degrees or more shall be considered as corners.
3. Braces and truss rods shall be securely fastened to posts with appropriate hardware.
4. Pull posts with two (2) braces shall be provided for all heights where changes in horizontal or vertical alignment of 10 degrees or more occur.

3.3 FABRIC

A. Do not install fabric until concrete post footings have cured seven (7) days. Provide fabric of the height specified. Install fabric on the public side of the fence, with bottom no greater than 2 inches above the ground surface. Fasten fabric to line posts at intervals not exceeding 15 inches with ties as specified.

B. Install tension wire in one (1) continuous length between pull posts, weaved through fence fabric at top and bottom. Tension wires shall be applied to provide a wire without visible sag

between posts. Fasten fabric to tension wires at intervals not exceeding 24 inches with ties or hog rings as specified.

C. Where it is not practicable to conform the fence to general contour of the ground, the opening beneath the fence shall be enclosed with chain link fabric and sufficiently braced to preclude access, but not to restrict the flow of water.

3.4 GATES

A. Provide swing gates at the locations and dimensions shown on the Drawings. Do not install gates until concrete post footings have cured seven (7) days.

B. Do not install gates until concrete post footings have cured seven (7) days.

C. Gates shall be installed plumb, level, and secure, with full opening without interference. Hardware shall be installed and adjusted for smooth operation and lubricated where necessary.

D. Provide concrete center drop to footing depth and suitable drop rod sleeve at center of double gate openings.

END OF SECTION 323110

SECTION 323120 - TRAFFIC CONTROL DEVICES

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 DESCRIPTION OF THE WORK

A. Provide all facilities, labor, materials, tools, equipment, appliances, transportation, supervision, and related work necessary to complete the Work specified in this section, and as shown on the Drawings.

B. The Work of this section includes the installation of new signs and sign supports and the removal of existing signs as indicated on the Drawings and specified herein. New signs and sign supports in public roadways, which will be within the jurisdiction of the State of Connecticut or the local municipality, shall conform to the requirements of Connecticut DOT Form 817, Sections 12.06, 12.07, 12.08, and 12.20 and the local Traffic Authority, as applicable.

1.3 SUBMITTALS

A. Shop Drawings

1. Submit shop drawings of all work of this Section. Do not order material or begin fabrication until the approval of the Owner's representative has been obtained.
2. Show the size and thickness of all members, types of materials, methods of construction, assembly method, type of surface treatment, complete dimensions, hangers, brackets, anchorage, relationship to surrounding work by other trades, shop finishes, sign designs, layouts, lettering, and other pertinent details of fabrication and installation.

1.4 QUALITY ASSURANCE

A. The approved manufacturer shall have experience in the type of work required; shall have a reputation for doing satisfactory work on time; and shall have recently successfully completed similar work.

B. Deliver and store work under these Sections in a manner to prevent cracking, chipping, or stress of the components, and to prevent mechanical damage or damage by the elements.

PART 2 - PRODUCTS

2.1 ALUMINUM SIGN PANELS

A. Aluminum sign panel shall be fabricated from flat aluminum sheeting, ASTM B 209-04, Alloy 6061-T6 or Alloy 5052-H38, of the following thickness and mounting, unless otherwise specified:

Area of Sign (square feet)	Mounting	Municipal Thickness (Inches)

< 10	Single Post	.080
Between 10 and 20	Two Posts	.080
Between 6 and 25	Single Post (Top Mounted)	.080

B. Sign supporting hardware shall be aluminum or stainless-steel.

2.2 REFLECTIVE SHEETING

A. Reflective sheeting shall meet the requirements of AASHTO M268.

1. Panel sheeting shall be Type II (Engineering Grade).
2. Legend sheeting shall be Type III (High Intensity).

2.3 LEGENDS

A. Permanently Applied Legends:

1. Permanently applied legends shall be reflective or opaque sheeting applied directly to clean, dust-free background in a manner specified by the sheeting manufacturer.
2. Heat activated adhesive-coated material shall be applied only by mechanical means.
3. Pressure sensitive, adhesive-coated materials shall be applied only by hand means.
4. Finishes shall be as recommended by and in a manner as specified by the sheeting manufacturer.
5. Legends shall be neatly cut.

2.4 SILK SCREEN PROCESSED

A. The legends shall be of the series and size specified in the AASHTO Manual for “Signing and Pavement Markings” (Current Edition), and the dimension and details of the letters with respect to each series shall be as specified in the FHWA publication “Standard Alphabet for Highway Signs” (Current Edition), or as shown on the Drawings.

2.5 FASTENERS AND ANCHORS

A. The sign fabricator shall design a complete system of fastenings and anchorage devices for the various signs, as required for attachment to the various supporting structures. These may include, but are not limited to, concealed clip systems, face screws, epoxy adhesives, etc. Wherever reasonably possible, fastenings and anchorage devices shall be fully concealed and shall be vandal proof. The Contractor is responsible to provide safe and secure installations in strict conformance to the governing laws and building code.

B. Fully describe proposed fastenings and anchorage devices for each sign type on the shop drawings.

2.6 SIGN SUPPORTS

A. Sign supports shall be of the breakaway type. Material for breakaway signposts shall be as specified in these Specifications and as required by the Owner’s representative.

B. Owner’s signs shall be mounted on Telspar posts within the concrete sidewalk. The posts shall be 1/8-inch-thick, 2-inch posts anchored in a 2-7/8-inch sleeve with a depth of 9-inches. All materials for public street signs shall conform to the local Traffic Authority standards.

PART 3 - EXECUTION

3.1 PROTECTION AND TEMPORARY COVERS

A. Completed sign panels shall be properly protected and maintained in good condition, free from dirt, scratches, hand marks, or other blemishes. The panels shall be shipped in such a manner as to insure their arrival on the job site in an undamaged condition.

B. Subsequent to erection, if directed by the Owner's representative, exterior signs may be required to be covered until the actual use thereof is desired. Material used to temporarily cover any sign panel shall effectively conceal the message and be non-injurious to the panel, its finish, or its structural integrity.

3.2 INSTALLATION

A. Erection of all work under this Section shall be performed by experienced sign erectors. Signs shall be installed true, plumb, and level, located as shown on the Drawings. No field cutting of any sign work will be allowed. Exercise extreme care in all handling and stacking of signs to avoid chipping. Exact location of signs will be determined by the Owner's representative in the field.

B. All work shall be rigidly anchored to the supporting construction, as indicated on the approved shop drawings.

3.3 ALUMINUM SIGN PANEL

A. Sign panels shall show careful workmanship and present a reasonably plane surface with the message and outlines clear and sharp.

1. Finished sign panels shall be shipped in such manner as to ensure arrival on the Project in undamaged condition, where they shall be properly protected from dirt, scratches, hand-marks, and other blemishes until erected and accepted.

B. Reflective sheeting shall be applied to properly treated base panels with mechanical equipment in a manner specified for the manufacture of traffic control signs by the sheeting manufacturer. Heat activated adhesive coating sheeting shall be pre-perforated.

1. No splices shall be allowed on sign panels.

C. When pressure sensitive adhesive coating reflective sheeting is used, all sheeting splices and sign edges shall be sealed with materials recommended by and in a manner specified by the sheeting manufacturer.

1. Dry heat activated adhesive coated reflective sheeting when applied to aluminum shall be edge sealed as specified by the sheeting manufacturer.

3.4 REFLECTIVE SHEETING

A. The reflective sheeting shall be applied to properly treated base panels with mechanical equipment in a manner specified by the sheeting manufacturer.

B. The numerals shall be black-die-cut, pre-spaced, conforming to the details on the Drawings and/or Owner's standards. Numerals shall have a pre-coated, pressure-activated adhesive applied as recommended by the manufacturer of the reflective sheeting or be opaque black permanent inks applied on approved high intensity sheeting.

C. Treatment of aluminum sign panels prior to application of reflective sheeting.

1. Vapor Degreasing: By total immersion of the panel in a saturated vapor or trichloroethylene. Trademark printing shall be removed with lacquer thinner or controlled alkaline cleaning system.
2. Alkaline Degreasing: By total immersion of the panel in a tank containing alkaline solutions, controlled and titrated to the solution manufacturer's specification.
3. Rinsing: After satisfactory degreasing, the panels shall be thoroughly washed with running water.
4. Drying: The panel shall be thoroughly dried by use of a forced hot air dryer.
5. Metal shall not be handled between cleaning and etching operation and the application of reflective sheeting, except with devices or clean canvas gloves.
6. Metal shall not come in contact with greases, oils, or other contaminants prior to the application of reflective sheeting.

3.5 CLEAN-UP

A. Surfaces of sign work shall be cleaned as recommended by the sign manufacturer after installation and left in a condition satisfactory to the Owner's representative.

B. All defective work, including that exhibiting cracked, chipped, scratched, abraded, or otherwise damaged finishes, shall be removed and replaced with work conforming to the specified requirements.

3.6 ERECTION OF POSTS

A. Posts shall be installed in conformance with details shown on the Drawings or as required by the local Traffic Authority.

B. Posts shall be driven a minimum of 3 feet into firm ground or shall be anchored in concrete in accordance with Owner's requirements.

C. Bottom of all signs shall be the minimum height above existing ground in accordance with MUTCD, latest edition, the local Authority or Connecticut DOT Form 816, whichever is more stringent.

END OF SECTION 323120

SECTION 329115 - SOIL PREPARATION

PART 1 – GENERAL

1.1 SECTION NCLUDES

A. The work shall include, but not be limited to the following:

1. Final grading of topsoil for finish landscaping.

2. Providing, leveling and compacting topsoil where sodding, seeding and planting is scheduled.

1.2 RELATED SECTIONS

A. Section 329200 - Turfs and Grasses

B. Section 329300 - Plants

1.3 SAMPLES

A. Submit 10 lb sample of topsoil to testing laboratory in air-tight containers. Provide laboratory results for soil properties, pH, organic content, and nutrient status for turf and horticulture with recommendations for amending to correct any deficiencies. Soil samples shall be certified as to their origin and there shall be multiple samples if they come from more than one source. The nearest qualified testing lab is the Ct. Agricultural Experiment Station, 123 Huntington St. New Haven, CT 06504.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Topsoil: friable, screened loam; free of subsoil, roots, grass, excessive amounts of weeds stone, and foreign matter; acidity range (pH) of 5.5 to 7.5; containing a minimum of 4 % and maximum of 25 % organic matter.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify site conditions and note irregularities affecting work of the section.

B. Beginning work of this Section means acceptance of existing conditions.

C. Examine grade stakes and reset, as needed to control placing and leveling of topsoil, maintaining grade stakes on 20 foot centers.

3.2 SUBSOIL PREPARATION

A. Eliminate uneven areas and low spots.

B. Remove debris, roots, branches, stones, in excess of 2 inches in size

C. Scarify subgrade to depth of 3 inches where topsoil is scheduled and equipment used for hauling and spreading topsoil and has compacted subsoil.

3.3 PLACING TOPSOIL

A. Place topsoil where seeding, sodding, or landscaping is scheduled to a nominal depth of 6 inches. Use topsoil in a relatively dry state, but moist enough so that soil structure is not destroyed when worked. Place topsoil during dry weather.

B. Fine grade topsoil eliminating rough or low areas. Maintain contour of subgrade.

C. Remove roots, weeds, rocks and foreign material after spreading, using mechanical stone picking machines, making passes over the entire area in two directions.

D. Manually spread topsoil close to trees, plants, and to prevent damage.

E. Lightly compact placed topsoil.

F. Remove surplus subsoil and topsoil from site.

G. Leave stockpile area and site clean and raked, ready to receive landscaping.

3.4 TOLERANCES

A. Top of Topsoil: Plus or minus 1/2 inch.

3.5 PROTECTION

A. Protect landscaping and other features remaining as final

work. B. Protect existing walls, walks, utilities and paving.

3.6 SCHEDULES

A. Compacted topsoil thickness: Seeded Grass: 6 inches.

B. Compacted topsoil thickness: Shrub beds: 12 inches.

END OF SECTION

SECTION 329200 - TURFS AND GRASSES

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. Seeding, mulching, and fertilizing.

B. Maintenance.

1.2 RELATED SECTIONS

A. Section 329115 - Soil Preparation: Preparation of subsoil and placement of topsoil in preparation for the work of this Section.

1.3 REFERENCES

A. The words "Topsoil and Seed" as called for on the contract drawings shall mean the work included in Section 329115 and this section.

1.4 QUALITY ASSURANCE

A. Provide seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging. Data to include percentages of purity, germination, and weed seed for each grass species.

B. Review topsoil test results obtained by contractor under Section 32915.

1.5 REGULATORY REQUIREMENTS

A. Comply with applicable regulatory agencies for fertilizer and herbicide composition.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Division 1.

B. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable.

C. Deliver fertilized in waterproof bags showing weight, chemical analysis, and name of manufacturer.

1.7 MAINTENANCE

A. Furnish maintenance of seeded areas immediately after seeding until grass is well established, usually after three cuttings.

PART 2- PRODUCTS

2.1 SEED MIXTURE

A. Seed Mixtures: See Drawings

2.2 SOIL MATERIALS

A. Topsoil: As specified in Section 329115.

2.3 ACCESSORIES

A. Fertilizer: Granular, non-burning, complete, guaranteed analysis fertilizer. Not less than 50% of the nitrogen shall be from organic sources. The fertilizer shall contain formulations of total nitrogen, available phosphoric acid and soluble potash in a 1:1:1: ration with an analysis of 10:10:10 in spring and a 1:2:1 ratio of
5:10:5 in the fall.

B. Water: Clean, fresh and free of substances or matter which could inhibit vigorous growth.

C. Herbicide: Tupersan; or approved equal, if spring or summer seeding..

D. Limestone: Ground limestone to contain not less than 85% of total carbonates and ground to a gradation such that 50% will pass a 100 mesh screen and 90% will pass through a 20 mesh screen.

E. Slope seeding protection: Curlex I Blanket by American Excelsior or approved equal.

2.5 TESTS

A. Provide topsoil analysis per Section 329115

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that prepared soil base is ready to receive the work of this Section. Seed bed shall have been thoroughly tilled and lightly rolled to insure finished lawns meet new grades called for on the grading plans. Incorporate lime when tilling.

3.2 PREPARATION

A. Apply fertilizer to supply one (1) pound of actual nitrogen per 1000 square feet.

B. Apply after smooth raking of topsoil. Refer to Section 329115.

C. Do not apply fertilizer at same time or with same machine as will be used to apply seed.

3.3 SEEDING

A. Apply seed at a rate of 5 lbs. per 1000 sq. ft. evenly in two (2) intersecting directions. Rake in lightly. Or use a mechanical seeding machine.

B. Do not seed areas in excess of that which can be mulched on same day.

C. Planting Season: Spring: March 15 to June 15; Fall: August 15 to Sept. 30

D. Do not sow immediately following rain, when ground is too dry, or during windy periods.

E. Roll seeded area with light roller if seeding machine is not used.

F. Immediately following seeding and compacting, apply mulch at 100 lbs. to 1000 s.f.

G.. Apply water with a fine spray immediately after each area has been mulched. Saturate to 6 inches.

3.4 SEED PROTECTION

A. Identify seeded areas with stakes and string around area periphery. Set string height to 30 inches. Space stakes at 15 feet.

B. Cover seeded slopes where grade is 4 inches per foot or greater with erosion fabric. Roll fabric onto slopes without stretching or pulling.

C. Lay fabric smoothly on surface, bury top end of each section in 6 inch deep excavated topsoil trench. Provide 12 inch overlap of adjacent rolls. Backfill trench and rake smooth, level with adjacent soil.

D. Secure outside edges and overlaps at 36 inch intervals with stakes.

E. Lightly dress slopes with topsoil to ensure close contact between fabric and soil. F.

At sides of ditches, lay fabric laps in direction of water flow. Lap ends and edges minimum 6 inches.

3.5 MAINTENANCE

A. Mow grass at regular intervals to maintain at a maximum height of 2-1/2 inches. Do not cut more than 1/3 of grass blade at any one mowing.

B. Neatly trim edges and hand clip where necessary.

C. Immediately remove clippings after mowing.

D. Water to prevent grass and soil from drying out.

E. Roll surface to remove minor depressions or irregularities.

F. Control growth of weeds. Apply herbicides in accordance with manufacturer's instructions. Remedy damage resulting from improper use of herbicides.

G. Immediately reseed areas which show bare spots.

H. Protect seeded areas with warning signs during maintenance period.

I. Maintenance period shall extend until the grass is formally accepted by the Engineer.

END OF SECTION

SECTION 334100 - STORM DRAINAGE SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Description of The Work

1. Provide all facilities, labor, materials, tools, equipment, appliances, transportation, supervision, and related work necessary to complete the Work specified in this Section, and as shown on the Drawings.
2. The Work of this Section shall include, but not be necessarily limited to, the installation of new storm drain pipe, manholes, and catch basins, the relocation/replacement of existing storm drain pipe and catch basins, connection of building roof drains and perimeter drains from a point 5 feet outside of the foundations, and the installation of under drain pipe all as shown on the Drawings, as directed by the Owner's representative, and as specified herein.

B. Related Sections

1. Carefully examine all the Contract Documents for requirements, which affect the Work in this Section. Other specification Sections, which directly relate to the Work of this Section include, but are not limited to, the following:

a. Section 312000 "Earth Moving"
b. Section 317000 "Maintenance and Protection of Traffic"
c. Section 321314 "Site Cast-in-Place Concrete"

1.3 SUBMITTALS

A. Shop Drawings

1. Materials list of items proposed to be provided under this Section.
2. Submit shop drawings or descriptive literature, or both, showing dimensions, joint, and other details of all materials to be furnished under this Section. Shop drawings shall be submitted to the Owner's representative for approval prior to ordering material.

B. As-Built Drawings

1. Submit two (2) copies of As-Built Drawings upon completion and acceptance of work.
2. As-Built Drawings shall be complete and shall indicate the true measurement and location, horizontal and vertical, of all new construction. As-Built drawings shall include a minimum of three (3) ties showing the distance to each catch basin and manhole, and the location of service connections measured from fixed permanent objects. As-Built drawings shall also contain any additional information required by the Owner's representative (including stamping by a licensed Professional Engineer or Land Surveyor as required).

1.4 COORDINATION

A. Coordinate the Work with the termination of storm sewer connections outside the buildings, connections to the existing storm sewer system, and trenching operations.

PART 2 - PRODUCTS

2.1 GENERAL

A. Reinforced Concrete Pipe: Pipe shall comply with the requirements of ASTM C 76-04a. All pipe 18 inches and smaller shall be Class V. All other pipe shall be Class IV unless indicated otherwise on the drawings.

1. Joints for the reinforced concrete pipe shall be the tongue and groove or bell and spigot type of joint and shall conform to ASTM C 443-03. All pipe shall have flexible, watertight rubber-type gaskets conforming to AASHTO M198.

B. Polyvinyl Chloride (PVC) Pipe: Only permitted when specifically indicated on the Drawings. Pipe and fittings shall comply with ASTM D 3034-04, rated SDR 35. Pipe shall be continually marked with manufacturer's name, pipe size, cell classification, SDR rating, and ASTM D 3034-04 classification.

1. Pipe joints shall be integrally molded bell ends in accordance with ASTM D 3034-04, Table 2, with factory supplied elastomeric gaskets and lubricant.

C. Ductile Iron Pipe: Pipe shall be ductile iron pipe, Class 52, per ANSI A21.51-02. Joints shall be push-on joints with synthetic rubber or neoprene gaskets per ANSI A21.11.

D. High Density Corrugated Polyethylene Pipe (HDPP) and Fittings with smooth interior shall meet the requirements of ASTM D 3350-04. Four-inch through 10-inch-diameter pipe corrugated polyethylene drainage tubing shall meet the requirements of AASHTO M252. 12-inch through 36-inch-diameter corrugated polyethylene pipe shall meet the requirements of AASHTO M294, Type S. Standard 45-degree "Y" connections shall be fabricated to sizes shown on the Drawings.

1. Pipe joints and fittings shall conform to the requirements of AASHTO M252 or AASHTO M294 and shall be bell and spigot type with rubber gasket and shall be soil tight in accordance with ASTM F 2306.

2.2 STORM DRAIN MANHOLES

A. Precast Units

1. Structure: 48-inch-diameter, unless otherwise noted, precast units (4,000 psi minimum compressive strength) with eccentric cone section tapering to 36-inch-diameter and one (1) pour monolithic base section per ASTM C 478-03a.

a. Wall thickness shall be a minimum of 5 inches.

2. Precast Unit Joint: Butyl rubber gasket joints shall be per ASTM C 990-03a.
3. Steps: Steps for manholes shall be steel reinforced copolymer polypropylene plastic with at least a 14-inch-wide stepping surface, per ASTM C 478-03a, D 4101-04, and A 615.
4. Manhole Frame and Cover: Grey iron casting per ASTM A 48-03, heavy duty, with word "DRAIN" on cover. Letter size shall be 2 inches. Frame and cover shall conform to the

Owner's representative standard, unless otherwise noted on the Drawings or directed by the Owner's representative.

B. Masonry Units

1. Brick shall conform to "Sewer Brick (Made from Clay or Shale)", ASTM C 32-04, Grade MS or "Building Brick" (Solid Masonry Units Made from Clay or Shale)", ASTM C 62-04, Grade SW.
2. Concrete block shall be solid block and shall conform to the "Specifications for Concrete Masonry Units for Construction of Catch Basins and Manholes," ASTM C 139-03, latest issue.
3. Mortar shall be in conformance with ASTM C 270-04a, Type M. The mortar shall be composed of Portland cement, hydrated lime, and sand, in the proportions of 1-part cement to ¼-part hydrated limit to 3½-parts sand (by volume).
4. Cement shall be Type I or II Portland Cement conforming to ASTM C 150-04, Standard Specification for Portland Cement. Where masonry is exposed to salt water, Type II shall be used.
5. Hydrated lime shall be Type S conforming to ASTM C 207-04.
6. Sand for masonry mortar shall conform to the gradation requirements of ASTM C 144-03.
7. Wall thickness for units over 10 feet deep shall be 12 inches. Inside dimensions shall remain the same.

2.3 CATCH BASINS

A. Precast catch basins shall be manufactured in accordance with ASTM C 478-03a (4,000 psi minimum compressive strength), the size and depth shall conform to the Connecticut DOT standard detail, unless otherwise noted on the Drawings.

B. When approved by the Owner's representative, catch basins may be constructed with brick or concrete block walls and poured reinforced concrete bases as an alternative to precast concrete units.

C. Brick and concrete block and other materials shall conform to Section 2.2B of these specifications.

D. Cast iron frames and grates for precast concrete units shall conform to the Connecticut DOT standard detail, unless otherwise noted on the Drawings or directed by the Owner's representative.

E. Catch basin traps shall conform to Neenah **Model R-3701**, LeBaron Oil and Grease Trap **Model L-219**, or Neenah **Model R-3707**, or approved equivalent.

2.4 STORMWATER CHAMBERS

A. Chambers shall be Cultec **150 XLHD** or approved equal.

B. Chambers shall be manufactured from virgin polypropylene or polyethylene resins tested using ASTM standards.

C. Chambers shall be designed in accordance with ASTM F 2787, standard practice for structural design of thermoplastic corrugated wall stormwater collection chambers.

D. Chamber rows shall provide continuous, unobstructed internal space with no internal support panels.

E. The structural design of the chambers, the structural backfill, and the installation requirements shall ensure that the load factors specified in the AASHTO LRFD bridge design specifications, Section 12.12 are met for 1) long-duration dead loads and 2) short-duration live loads, based on the AASHTO design truck with consideration for impact and multiple vehicle presence.

F. Chambers shall be produced at an iso 9001 certified manufacturing facility.

G. All design specifications for chambers shall be in accordance with the manufacturer's latest design manual.

2.5 HYDRODYNAMIC SEPARATOR

A. The hydrodynamic separator shall be Stormceptor **STC 900**, or approved equal, conforming to the following requirements:

1. General: The separator shall be circular and constructed from pre-cast concrete circular riser and slab components. The internal fiberglass insert shall be bolted and sealed watertight inside the reinforced concrete component. The separator shall be capable to be used as a bend or junction structure within the stormwater drainage system.
2. Precast Concrete Sections: All precast concrete components shall be designed and manufactured to a minimum live load of AASHTO HS-20 truck loading or greater based on local regulatory specifications.
3. Joints: The concrete joints shall be water-tight and meet the design criteria according to ASTM C 443. Mastic sealants or butyl tape are not an acceptable alternative.
4. Frame and Cover: The frame and cover shall include an indented top design with lettering of the unit’s name cast into the cover to allow for easy identification in the field.
5. Concrete: All reinforced concrete components shall be manufactured according to local specifications and shall meet the requirements of ASTM C 478.
6. Fiberglass: The fiberglass portion of the water treatment device shall be constructed in accordance with the following standard: ASTM D 4097: Contact Molded Glass Fiber Reinforced Chemical Resistant Tanks.
7. Inspection: All precast concrete sections shall be inspected to ensure that dimensions, appearance, and quality of the product meet local specifications and ASTM C 478

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

A. As soon as the excavation is completed to the normal grade of the bottom of the trench, the Contractor shall immediately place the bedding material in the trench. Then the pipe shall be firmly bedded in the compacted bedding material to conform accurately to the lines and grade indicated on the Drawings.

B. Install pipe, fittings, and accessories in accordance with manufacturer’s instructions.

C. Notch under pipe bells and joints, where applicable to provide for uniform bearing under entire length of pipe.

D. Excavation, backfilling, and compaction shall be as specified in Section 312000 “Earth Moving” of these Specifications.

E. Maintain optimum moisture content of bedding material to attain required compaction density.

3.2 MANHOLES AND CATCH BASINS

A. Manholes and Catch Basins shall be constructed at the locations and to the lines, grades, and dimensions noted on the Drawings, or as required.

B. Precast concrete construction shall be done in a manner to ensure watertight construction and all leaks in precast concrete shall be sealed. If required, precast concrete shall be repaired or replaced to obtain watertight construction.

C. Concrete barrels and cones shall be precast concrete sections.

1. Bases shall be either precast with a barrel integrally cast with the base, or poured concrete suitably shaped by means of accurate bell-rung forms to receive the barrel sections. Manhole invert channels in manholes shall be formed in concrete.
2. Precast manholes shall have an adjustment ring at the top of the cone to permit the frame and cover to meet the finished surface. This shall consist of courses of brick or reinforced grading rings not to exceed 11 inches.

D. Stubs shall be short pieces cut from the bell ends of the appropriate size and class of pipe. Concrete stubs shall be plugged with brick masonry unless otherwise directed.

E. Manhole inverts shall conform accurately to the size of the adjoining pipes.

1. Manhole inverts shall be constructed of concrete developing 3,500 psi with the concrete being placed to the spring line of the pipe form.
2. Smooth plastic pipe, matching the dimension of the outlet pipe, shall be used to form the invert.
3. Side inverts and main inverts, where the direction changes, shall be laid out in smooth curves of the longest possible radius, which is tangent, within the manhole, to the centerline of adjoining pipelines.
4. Invert shelves shall be graded to provide a 1-inch per 1-foot wash from the manhole walls.

F. Manhole sections shall contain manhole steps accurately positioned and embedded in the concrete when the section is cast. Precast-reinforced concrete manhole sections shall be set so as to be vertical and with sections and steps in true alignment.

G. All holes in sections used for their handling shall be thoroughly plugged with rubber plugs, made specifically for this purpose, or with mortar. The mortar shall be 1-part cement to 1½-parts sand, mixed slightly damp to the touch (just short of “balling”), hammered into the holes until it is dense and an excess of paste appears on the surface, and then finished smooth and flush with the adjoining surfaces.

H. The Contractor may, as an alternate to suitable non-shrink mortar joints, use premolded elastomeric-sealed joints for pipe into precast manhole bases.

1. All materials, accessories and construction methods used in making the joints shall be supplied or approved by the manufacturer of the premolded elastomeric-sealed joint.

I. Openings for pipe and materials to be embedded in the walls of the base for these joints shall be cast in the base at the required locations during the manufacturer of the base. Incorrectly cast and patched pipe openings will be rejected.

J. Manhole risers and tops shall be installed using approved “o-ring” type, neoprene gaskets for sealing joints. Units shall be installed level and plumb. Water shall not be permitted to rise over

newly made joints nor until after inspection as to their acceptability. All jointing shall be done in a manner to insure water tightness.

K. Openings shall be provided in the risers to receive entering pipes. These openings may be made at the place of manufacture. The openings shall be sized to provide a uniform 1-inch maximum annular space between the outside of the pipe wall and the opening in the riser. After the pipe is in position, the annular space shall be solidly filled with non-shrink mortar. Care shall be taken to assure that the openings are located to permit setting of the entering pipe at its correct elevation as indicated.

L. Openings, which are cut in the risers in the field, shall be carefully made by coring so as not to damage the riser. Damaged risers will be rejected and shall be replaced at no additional expense to the Owner.

M. Where required by the Drawings, a slot and opening shall be cast in the catch basin wall suitable for mounting the cast iron hood and discharge pipe. The hood hinge may be furnished to the precast supplier by the Contractor for incorporation into the casting during manufacture.

3.3 BRICK MASONRY

A. Brick masonry construction shall be done in a manner to ensure watertight construction and all leaks in brick masonry shall be sealed. All workmanship shall conform to the best standard practice and all brick masonry shall be laid by skilled workmen.

B. All beds on which masonry is to be laid shall be cleaned and wetted properly. Brick shall be wetted as required and shall be damp but free of any surface water when placed in the Work. Bed joints shall be formed of a thick layer of mortar, which shall be smoothed or furrowed slightly. Head joints shall be formed by applying to the brick to be laid a full coast of mortar on the entire end, or on the entire side as the case requires, and then shoving the mortar covered end or side of the brick tightly against the bricks laid previously. The practice of buttering at the corners of the brick and then throwing the mortar or scrapings in the empty joints will not be permitted. Dry or butt joints will not be permitted. Joints shall be uniform in thickness and shall be approximately 1¼-inch-thick.

C. Brickwork shall be constructed accurately to dimensions and brickwork at top of manholes shall be to the dimensions of the flanges of the cast-iron frames.

D. Joints on the inside face of walls shall be tooled slightly concave with an approved jointer when the mortar is thumbprint hard. The mortar shall be compressed with complete contact along the edges to seal the surface of the joints.

E. All castings to be embedded in the brickwork shall be accurately set and built-in as the Work progresses. Cast-iron frames and manhole covers shall be well bedded in mortar and accurately set to finished graded indicated or as directed.

F. Water shall not be allowed to flow against brickwork or to rise on the masonry for 60 hours after it has been laid, and any brick masonry damaged in this manner shall be replaced as directed at no additional expense to the Owner. Adequate precautions shall be taken in freezing weather to protect the masonry from damage by frost.

3.4 CONCRETE MASONRY UNITS

A. Concrete masonry unit construction shall be soaked in water before laying. As circular concrete block walls are laid-up, the horizontal joints and keyways shall be flushed full with mortar. As rectangular blocks are laid-up, all horizontal and vertical joints shall be flushed full with mortar.

Plastering of the outside of block structures will not be required. The joints in precast units shall be wetted and completely mortared immediately prior to setting a section. No structure shall be backfilled until all mortar has completely set.

3.5 MANHOLE STEPS

A. Placement of steps into the precast walls shall be by a proven method as recommended by the supplier of the precast manhole sections. Details of the steps and method of placement shall be submitted for approval.

B. Plastic steps shall be placed into the wet concrete wall during manufacture or if designed for press fit installation shall be driven into a wall opening according to the manufacturer's specifications. Steps shall not be mortared into place after the concrete has set.

C. All manholes, catch basins, lawn inlets, etc., which are in excess of 5 feet in depth, shall be constructed with standard aluminum steps, spaced at 12-inch on center.

3.6 DROP INLETS

A. Drop inlets shall be constructed to the lines, grades, dimensions, and design at the locations indicated on the plans or as required.

B. The Owner's representative may permit brick or concrete masonry construction. If this alternate is being employed, construction shall be done in accordance with Paragraphs 3.3 or 3.4 in this Section.

3.7 STORMWATER CHAMBERS

A. The installation of the chambers shall be in accordance with the manufacturer's latest installation instructions.

3.8 HYDRODYNAMIC SEPARATOR

A. The hydrodynamic separator shall be installed at the location shown on the Drawings in accordance with the manufacturer's standard installation requirements.

B. The hydrodynamic separator shall be constructed in accordance with the details shown on the Drawings.

C. A representative of the hydrodynamic separator manufacturer and the design engineer must inspect the installation after the contractor has installed the separator to ensure that the separator was installed as designed.

3.9 CASTINGS

A. Cast-iron frames for grates and covers shall be well bedded in cement mortar and accurately set to the grades indicated or as directed. The frames shall be encased with a thick cement-mortar collar around the entire perimeter of the frames.

B. All voids between the bottom flange shall be completely filled to make a watertight fit. A ring of mortar, at least 1-inch-thick and pitched to shed water away from the frame shall be placed over and around the outside of the bottom flange. The mortar shall extend to the outer edge of the masonry all around its circumference and shall be finished smooth. No visible leakage will be permitted.

C. Structures within the limits of bituminous concrete pavement shall be temporarily set at the elevation of the bottom of the binder course or as ordered. After the binder course has been compacted, these structures shall be set at their final grade. Backfill necessary around such structures after the binder course has been completed shall be made with Class A concrete unless otherwise ordered.

3.10 CLEANING

A. At the completion of the Work, clean all piping, structures, and open drainage courses, through and to which water from this construction is directed, to the satisfaction of the Owner's representative.

3.11 AS-BUILT DRAWINGS

A. As work progresses, record on two (2) sets of plans all changes and deviations from the Contract Drawings in size, line, and grade. Make sufficient measurements to locate the Work completed. Record on the plans, any uncharted locations of utilities encountered during installation of the storm drainage system (denote utility type, size, material, etc.). Deliver the plans to the Owner's representative.

END OF SECTION 334100

SECTION 334300 – SITE WATER UTILITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and other Division 1 Specification Sections, apply to this Section.

B. Installation of fire protection piping shall comply with “NFPA 24, Private Fire Service Mains and their Appurtenances” and “Factory Mutual Data Sheet 3-10, Fire Service Mains”.

1.2 DESCRIPTION

A. This Section specifies requirements for the proposed water system pipe, fittings, appurtenances and services.

B. The work includes:

1. Furnishing and installation of new domestic water piping, valves and valve boxes, pipe fittings, anchors, thrust blocks, required accessories and connections to existing water systems.

2. Disinfection and testing of the system.

1.3 RELATED SECTIONS

A. Carefully examine all of the Contract Documents for requirements, which affect the Work in this Section. Other Specification Sections, which directly relate to the Work of this Section include, but are not limited to, the following:

1. Section 312000 – Earth Moving

2. Section 334200 – Sanitary Sewers

3. Section 321314 - Site Cast-in-Place Concrete

1.4 COORDINATION WITH THE LOCAL WATER AUTHORITY’S REPRESENTATIVE

A. The Local Water Authority shall be notified prior to starting construction for a connection to, or extension of, any portion of the domestic or fire protection water systems.

B. The closing of valves necessary for making connections with the existing water systems will be done by the Contractor with the assistance of the Local Water Authority. Sufficient notice shall be given the Local Water Authority for a planned connection. No allowance will be made for any delay in the closing of valves. A 48-hour notice shall be given to adjacent buildings/residences affected by the shutdown, and shall be done by the Contractor under the direction of the Local Water Authority’s representative. The Local Water Authority’s representative may require the work be done at night during the low use time period.

C The Contractor shall pay all costs for all testing, flushing, chlorinating, laboratory analyses, sampling, water supply and connection charges as well as any charges associated with the use of a Local Water Authority “Approved” Contractor to perform any or all of the required work.

1.5 SUBMITTALS

A. Shop Drawings

1. Submit Shop Drawings or descriptive literature, or both, showing dimensions, joints and other details of all pipe materials and appurtenances to be furnished. Shop Drawings shall be submitted to the Local Water Authority for approval prior to ordering materials.

B. As-Built Drawings

1. Submit 3 copies of As-Built Drawings upon completion and acceptance of work.

2. As-Built Drawings shall be complete and shall indicate the true measurements and locations, horizontal and vertical, of all new construction. As-Built Drawings shall include a minimum of three ties to each gate valve box from fixed permanent objects. As-Built Drawings shall also contain the location of service lines and any additional information required by the Local Water Authority’s representative, and shall be stamped with the seal of a Licensed Land Surveyor or Licensed Professional Engineer.

1.6 DELIVERY, STORAGE AND HANDLING

A. Storage of pipe, fittings, valves, hydrants and other water line appurtenances on the site shall be in accordance with the manufacturer's recommendations, subject to the approval of the Owner’s representative.

B. Care shall be taken in loading, transporting and unloading to prevent injury to the pipe, fittings, valves, hydrants, and other water line appurtenances. Pipe or fittings shall not be dropped. All pipe or fittings shall be examined before laying and no piece shall be installed which is found to be defective. Any damage to pipe and fitting coatings shall be repaired as directed by the Local Water Authority’s representative.

C. Pipe, fittings, valves, hydrants and other water system appurtenances which are defective from any cause, including damage caused by handling, and determined by the Owner’s representative as non-repairable, shall be unacceptable for installation and shall be replaced at no cost to the Owner.

D. Pipe, and all water system appurtenances that are damaged or disturbed through any cause prior to acceptance of the work shall be repaired, realigned or replaced as required by the Local Water Authority’s representative at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 GENERAL

A. The Drawings are diagrammatic only and are intended to indicate the extent, but not all details, of the system, which shall be constructed. All materials and fittings are not shown; but the Contractor shall furnish and install all materials and fittings required for the complete system.

B. All work, materials and fittings shall comply with the latest edition of the Local Water Authority Standard Details. In the event of a conflict between these specifications, the project drawings and details and the Local Water Authority's Standard Details, the Authority's Standard details shall prevail.

2.2 WATER SERVICE

A. Services two inches or smaller shall be copper water tubing, Type K, for underground water service and shall be in accordance with AWWA C800-01.

B. Water service fittings, including couplings and adapters, check valves and service saddles shall be in conformance with AWWA C800-01, Underground Service Line Valves and Fittings.

C. Joints in copper tubing shall be made with three part compression couplings or an approved equal.

D. Services 3 inches and greater shall be ductile iron pipe.

2.3 BACKFLOW PREVENTERS

As required by the Local Water Authority's representative. Refer to Plumbing Specifications.

2.4 PRESSURE REDUCING VALVES

None Required

2.5 METERS

As required by the Local Water Authority's representative. Refer to Plumbing Specifications.

PART 3—EXECUTION

3.1 GENERAL

A. All water pipes, fittings, valves, hydrants and other appurtenances shall be installed at the locations as shown on the Drawings and/or directed by the Local Water Authority's representative.

The proposed location and vertical alignment may be altered to avoid conflicts with existing and proposed utilities, as approved by the Local Water Authority's representative.

3.2 LAYING COPPER WATER SERVICE PIPE

A. Copper pipe and fittings shall be installed in accordance with the requirements of AWWA C600-99.

B. Each length of pipe shall be laid with firm, full and even bearing throughout its entire length, in a trench prepared and maintained in accordance with Section 312000, Earth Moving. The type of materials to be used in bedding and backfilling and method of placement shall conform to the requirements of Section 312000, Earth Moving and the details.

C. All pipe shall be clean before laying. When installation is stopped for any reason, the open ends of the pipe shall be closed by watertight plugs or other approved means. If water is in the trench when work is resumed, the plug shall not be removed until the trench has been dewatered and all danger of water entering the pipe has been eliminated.

D. Fittings, in addition to those shown on the Drawings, shall be provided if required to avoid utility conflicts.

E. The pipe shall be laid with a minimum cover of 4.5-feet below finished grade, unless otherwise required by the Southeastern CT Water Authority's representative.

3.3 WATER / SANITARY SEWER SEPARATION

When a sewer pipe crosses above or below a water pipe, the following procedures shall be utilized. The Contractor shall comply with these following procedures:

A. Relation to Water Mains

1. *Horizontal Separation*: Whenever possible, sewers shall be laid below, and at a minimum at least 10 feet, horizontally, from any existing or proposed water main. Should local conditions prevent a lateral separation of 10 feet, a sewer may be laid closer than 10 feet to a water main if:

   a. It is laid in a separate trench, or if

   b. It is laid in the same trench with the water main located at one side on a bench of undistributed earth, and if

   c. In either case, the elevation of the top (crown) of the sewer is at least 18 inches below the bottom (invert) of the water main.

2. *Vertical Separation*: Whenever sewers must cross under water mains, the sewer shall be laid at such an elevation that the top of the sewer is at least 18 inches below the bottom of the water main. When the elevation of the sewer cannot be varied to meet the above requirements, the water main shall be relocated to provide this separation or reconstructed with mechanical-joint pipe for a distance of 10 feet on each side of the sewer. One full length of water main should be centered over the sewer so that both joints will be as far from the sewer as possible.

   When it is impossible to obtain horizontal and/or vertical separation as stipulated above, both the water main and sewer shall be constructed of mechanical-joint cement lined

ductile iron pipe, or other equivalent based on watertightness and structural soundness. Both pipes shall be pressure tested by an approved method to assure watertightness, or both pipes shall be encased in concrete.

3.4 PRESSURE TESTING

A. Hydrostatic and leakage test shall be conducted in accordance with AWWA Standard C600-99 and C900-97, and as directed by the Local Water Authority's representative. Testing shall be conducted by a certified Independent Water Testing Company.

B. Conduct pipe tests after concrete thrust blocks have cured to the required 3000-psi strength. Fill pipe 24 hours prior to testing, and apply test pressure to stabilize system. Use only potable water.

C. Prior to pressure testing, the entire pipe section shall be flushed to remove any rocks or debris, which may have inadvertently entered the pipe during construction.

D. Once the pipe section has been filled at normal pressure and all entrapped air removed, the Contractor shall raise the pressure to 150 psi or two times the operating pressure (whichever is greater) by a special pressure pump, taking water from a small tank of proper dimensions for satisfactorily measuring the rate of pumping into the pipe. This pressure shall be maintained for a minimum of 2 hours, during which time the line shall be checked for leaks. Measured rate of water leakage shall not exceed the allowable leakage listed below.

Allowable leakage in gallons per hour, per 1,000 feet of exterior pipeline:

Test Pressure	Nominal Pipe Diameter [inches]					
	4	6	8	10	12	16
150 psi	0.36	0.55	0.74	0.92	1.10	1.47

Interior piping in vaults, buildings, etc. shall have zero leakage.

Should leakage exceed this rate, the Contractor shall immediately locate the leak or leaks and repair them. Pipe will be accepted only when leakage is zero, or less than the allowable amount. Approval does not absolve the Contractor from responsibility if leaks develop later within the period of warranty.

3.5 Disinfection

A. Before being placed in service, all new water pipe shall be chlorinated in accordance with AWWA C651-99 Standard for Disinfecting Water Mains or the Local Water Authority's requirements/regulations, whichever is the more stringent.

B. The location of the chlorination and sampling points will be determined by the Local Water Authority's representative in the field. Taps for chlorination and sampling shall be installed by the Contractor. The Contractor shall uncover and backfill the taps as required.

C. The pipe section being disinfected shall be flushed to remove discolored water and sediment from the pipe. A 25-mg/l chlorine solution in approved dosages shall be inserted through a tap at one end while water is being withdrawn at the other end of the pipe section. The chlorine concentration in the water in the pipe shall be maintained at a minimum 25-mg/l available chlorine during filling. To assure that this concentration is maintained, the chlorine residual shall be measured at regular intervals in accordance with procedures described in Standard Methods and AWWA M12, Simplified Procedure for Water Examination [Section K].

D. During the application of the chlorine, valves shall be manipulated to prevent the treatment dosage from flowing back into the pipe supplying the water. Chlorine application shall not cease until the entire pipe section is filled with chlorine solution. The chlorinated water shall be retained in the pipe for at least a twenty-four hour period. The treated water shall contain chlorine residual throughout the length of the pipe section as indicated in AWWA C651-99.

E. Following the chlorination period, all treated water shall be flushed from the pipe section and replaced with water from the distribution system. Prior to disposal of treated water the Contractor shall check with local authorities to determine if the discharge will cause damage to the receiving body or sewer and, if required, the Contractor shall neutralize the chlorinated water in accordance with AWWA recommendations. Bacteriological sampling and analysis of the replacement water may then be made by the Contractor in full accordance with AWWA C651-99. A minimum of three samples shall be taken by the Contractor at locations directed by the Local Water Authority's representative along the length of water pipe being chlorinated and sent to a State approved private laboratory for analyses. The Contractor shall rechlorinate if the samples show presence of coliform, and the pipe section shall not be placed in service until all of the repeat samples show no presence of coliform.

F. Furnish two copies of a Certificate of Disinfection Report to the Owner's representative and one copy to the Local Water Authority's representative.

G. The Contractor shall pay all costs for all testing, flushing, chlorinating, laboratory analyses, sampling, water supply and connection charges as well as any charges associated with the use of a Local Water Authority "Approved" Contractor to perform any or all of the required work.

END OF SECTION 334300